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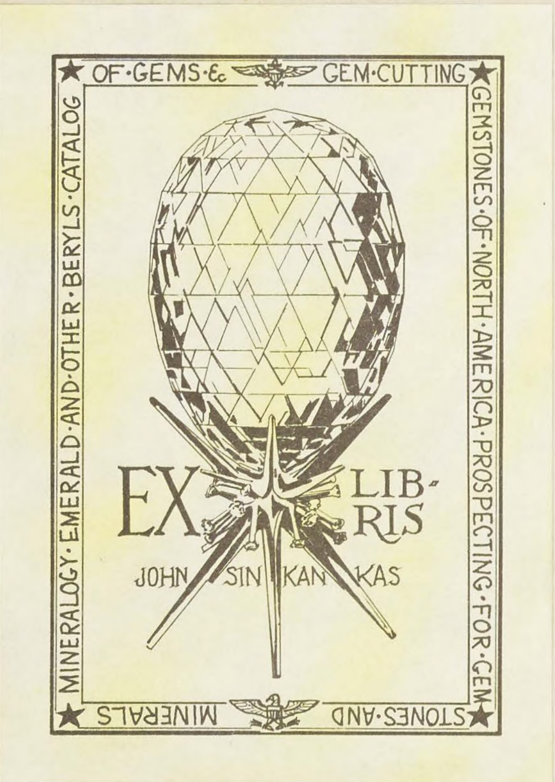


Thos. Northmore
Septr. 1805.

A

PRACTICAL ESSAY

ON THE

ANALYSIS OF MINERALS.

By FREDRICK ACCUM.

PRICE 7*s*.

A

PRACTICAL ESSAY

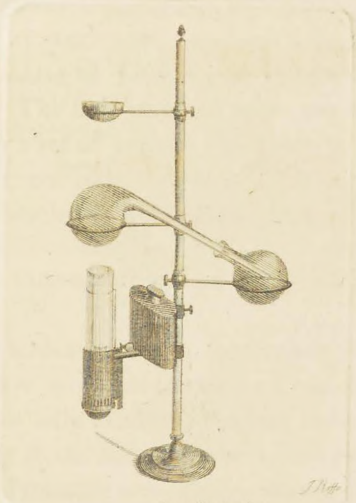
ON THE

ANALYSIS OF MINERALS,

Exemplifying
THE BEST METHODS OF ANALYSING
ORES, EARTHS, STONES, INFLAMMABLE FOSSILS,
AND MINERAL SUBSTANCES IN GENERAL.

By FREDRICK ACCUM,

Teacher of Practical Chemistry, Pharmacy, and Mineralogy.



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PREFACE.

Old Compton Street, Soho.

THIS Essay is printed by express desire of a number of gentlemen, to whom I delivered a private course of Lectures on Practical Chemistry. The task imposed upon me was, to draw up a set of concise directions to enable a person, not intimately acquainted with analytical chemistry, to examine such unknown minerals as he may meet with, so as readily to ascertain their nature and principal component parts.

While endeavouring to accomplish this object, I have surpassed the limits I had in view. I have not only exhibited the best methods of analysing all the different genera, and principal species of metallic ores, earths, stones, inflammable fossils, and mineral salts, frequently met with; but I have also given examples to elucidate the analysis of such minerals as are less abundant, or are less frequently found in nature. The student will thus become enabled to examine all the different mineral substances which constitute the solid part of the globe which we inhabit; so as to determine not only the nature, but also the class, genus, and species to which an unknown mineral belongs, according to any of the adopted systems of mineralogy.

The minerals selected as subjects of experiment, have been considered merely with regard to their chemical habitudes; that is to say, abstractedly from all external characters. The names adopted by Kirwan are retained, in order that the works of these authors may be consulted with facility.

I do not flatter myself that I have in every instance accomplished the end I had in view, but I am confident that the general methods, and practical rules here pointed out, will prove useful to the student of mineralogy and chemistry.

LONDON, FRED. ACCUM.
1804.

ERRATA.

Preface, page vi, *for* " these authors," *read* " this author."

Page 7, line 11, *for* "analysist's," *read* "analyst's."

—— 10, —— 25, *for* "glass spheres," *read* "sections of glass spheres."

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PRELIMINARY OBSERVATIONS.

THE name of MINERAL is given to all those inorganic, and inanimate substances, which form the solid mass, or rather the external covering of the globe which we inhabit; so far at least as the labour of man has hitherto penetrated.

The art of describing minerals with such accuracy and precision as is sufficient to distinguish them from each other, by means of their external, or obvious physical characters, constitutes the science of MINERALOGY.

The art of examining minerals by the application of chemical agents, so as to acquire a knowledge of all their constituent parts which nature had concealed from our view, forms a branch of practical chemistry, called *the analysis of minerals*

This latter field of inquiry at first sight appears immense and intricate. But the great progress which chemistry has made during our own time, has greatly facilitated this branch of philosophical inquiry. That it may be accomplished with tolerable accuracy, even by persons not deeply skilled in chemical pursuits is the intent of this essay.

GENERAL NATURE OF THE OPERATIONS AND INSTRUMENTS OF ANALYSIS.

Before we proceed to exhibit the methods made use of by chemists in analysing minerals, we shall give a short account of those general processes and instruments to which it is necessary to have continually recourse in almost every analysis.

The chemical examination of minerals consists in a series of operations, calculated either to separate the constituent parts of the body under examination from each other, and exhibit them to our view in a detached state, or to cause them to form new compounds. The methods employed for this purpose consist in subjecting the mineral to the action of certain bodies which are capable of producing some positive changes amongst its constituent parts. The substances employed are called *Chemical-Reagents*, or *Tests*. These bodies when properly applied quickly produce a change striking to the senses, from which we infer the presence or absence of certain bodies. The action of tests therefore facilitates and guides our inquiry; no chemical analysis can possibly be made without them; they are the compass by which the chemist steers.

Besides these agents which may be considered as the *active instruments of experiment*, the chemist must be in possesion of a variety of other instruments, which properly speaking, possess no positive power, but which principally serve for conducting, and facilitating the operations necessary for the practice of his science. The instruments of this kind are called *chemical apparatus.*

It was once thought that for the purpose of experimental inquiry, particularly of this nature, a place or laboratory, regularly fitted up with furnaces and other apparatus was absolutely necessary. But this is by no means the case. The great improvements which have been made in analytical chemistry have superseded this necessity; and it is now universally admitted that all the operations of analysis may be (in the small way) conveniently performed, by the help of a few instruments, in the closet of the amateur of the science; and that even all the apparatus, re-agents, and other articles of experiment, necessary for the analysis of minerals, may be comprised in a convenient travelling chest. (See page 24.)

When the object is to analyse a mineral; for instance an ore, particularly with a view to ascertain the comparative richness with respect to the metal it contains, it is absolutely necessary that specimens of the ore, be taken, from the richest, the poorest, and from that which seems to be of middling quality. This precaution is indispensible, because were the analysis made with a rich specimen, it might raise too flattering expectations; or if with a poor one, it might produce discouragement.

The next step in the analysis of any kind of mineral, consists in separating the substance intended to be examined, from all kind of extraneous matters, with which it is always more or less united. They may be separated by picking, washing, or other mechanical operations; in order that the mineral may be examined pure or unmixt. This being done its specific gravity must be ascertained. The method of accomplishing this, may be seen (page 29). The substance employed should then be reduced to an impalpable powder by means of the pestle and mortar. This operation is called *pounding*, or *pulverisation*. The bottom of mortars should be concave, and their sides neither so inclined as to allow the substance operated on, to fall to the bottom, between each stroke of the pestle, nor so perpendicular as to collect it too much together and retard the operation. A steel or iron mortar, is convenient for dividing large specimens of minerals into smaller pieces, to render them more fit for being reduced to a finer powder in a smaller mortar of Wedgwood's ware, or agate.

Trituration differs from the process of pulverisation, only in degree; it is performed by giving a rotatory motion to the pestle.

Levigation differs from trituration in the addition of water to the powder operated upon; so as to form the whole mass into a tenacious, or rather liquid paste, which is rubbed in the mortar till it is as fine as required. Very hard substances particularly all stones of the silicious genus must be repeatedly heated to redness, and then suddenly quenched in cold water, in order to render them sufficiently friable.

Weighing. The quantity of substance thus previously comminuted, should next be accurately determined by the process called *weighing*: for that purpose the operator should be provided with a good balance, and an accurate set of weights. The beam of a good balance should remain in equilibrio without the scales, and when the scales are changed, and should turn sensibly with a small portion of additional weight when loaded. Scales must be defended as much as possible from acid vapours, as their delicacy is impaired by them: for the same reason they never should be overloaded. It is of the utmost consequence in every analysis, to ascertain at all times the precise quantity of any matter which is subjected to examination, and again to distinguish with equal accuracy the quantities of the products. Hence the instruments for weighing are to be regarded as particularly deserving of the young analysist's attention.

Solution is a most general process of analysis. It is the diminution of the aggregation of any solid substance, in consequence of its entering into a new chemical combination. This process consists in affusing upon the substance to be dissolved, a fluid employed as solvent; suffering it to stand in the cold, or assisting the action of the bodies upon each other by heat, according to the nature of the substance. Solution may be performed in glass matrasses, or Florence flasks. The vessel employed should not be above $\frac{1}{3}$ full. It should be tied over with a piece of wet bladder, and pierced with one or more small holes made with a pin, so that the evaporation of the fluid may be retarded as much as possible. The flask may be heated over the lamp-furnace, (see title page). Solution is accelerated by shaking and agitating the mixture. Perfect transparency and permanent suspension of the solid, are marks of perfect solution, by which it is distinguished from simple mixture, or mechanical diffusion.

Precipitation is the reverse of solution. It consists in separating a dissolved body, from the solvent or substance which held it in solution by the intervention of another body. The substance separated is called the precipitate. Long conical glasses answer very well for this process.

Filtration is employed for separating solids from fluids, particularly when the former do not subside, or at least very slowly. To filter substances, white paper freed from size, alum, &c. (filtering paper,) is folded in a conical form, called a filter, and placed in a glass funnel. The substance to be filtered is then poured upon the filter gradually. That part of the fluid which passes first, is seldom clear; it must therefore be poured back again upon the filter, until by the swelling of the fibres of the paper, the fluid acquires complete transparency. It is of advantage in filtration to introduce glass-rods, bleached pack-thread, or straw, between the filter and the funnel, to prevent the paper from adhering too closely to the latter. Acids, alcalies, and other corrosive fluids, are best filtered by means of a glass funnel filled with pounded glass, a few large pieces being first put in the neck of the funnel, smaller ones over these, and the finer powder placed over all. The porosity of this kind of filter retains much of the fluid, but it may be recovered by gently pouring on it as much water; the fluid will then be displaced and pass through, and the water be retained in its place.

Decantation differs from filtration merely in degree, it is the expedient by which such fluids are separated from solids, as differ considerably in specific gravity. The heavier body falling to the bottom speedily, so as to allow the supernatant fluid to be decanted, either wholly or in part, without disturbing the heavier part. Decantation is best performed from tall cylindrical glass vessels, furnished with a spout or lip.

Elutrition is confined to such mineral substances on which water has no action. It is performed for separating them from foreign particles and impurities of a different specific gravity, in which case they are said to be washed; or for separating the impalpable powders obtained by trituration and levigation, from the coarser particles. This process depends upon the property that very fine, or light powders have of remaining for some time suspended in water; and is performed by diffusing the powder, or paste, formed by levigation through plenty of water, letting it stand a sufficient time until the coarser particles settle at the bottom, and then pouring off the liquid in which the finer or lighter particles are suspended. (See analysis of gold dust, page 35.) Fresh water may be poured on the residuum, and the operation repeated: or the coarser particles which fall to the bottom may be previously levigated a second time.

Evaporation is a chemical process intended for separating volatile, from fixed bodies, by converting the former into vapour by means of heat. It is performed in glass spheres, or shallow basons of Wedgwood's-ware, supported by the rings of the lamp-furnace; (see title vignette.) Small quantities of fluids may be conveniently evaporated in watch glasses, whose absolute weight is marked on the outside by means of a diamond. Evaporation is promoted by enlarging the surface of the fluid, and by agitation.

Distillation is a process of evaporation performed in close vessels, so as to collect the products. Distillation is performed by means of a *Retort* and *Receiver*. The retort is a globular vessel either of glass, or earthen-ware, with a neck extending in a curved direction from one side of the globe, terminating in an open point or mouth. (See title vignette). The materials to be distilled are introduced into the body of the retort, and heat is applied, to cause the substance to boil. To the neck of the retort is adapted a receiver, or globular vessel, with a short straight neck, wide enough to allow the neck of the retort to be introduced into it. (See title vignette.) It is intended to condense and receive from the retort, the fluid that distils over.

Abstraction is that species of distillation in which a fluid once distilled, is again distilled off, from the same substance, from which it was obtained.

Reduction is the operation employed for restoring oxids of metals to the metallic state by the intervention of another body, which acts chemically upon them. It is performed in crucibles, or other vessels, by the action of heat, and interposition of different substances.

Roasting or *Ustulation* is a process to be performed upon metallic ores, by exposing them in a crucible, or other convenient vessel to the action of heat in contact with air. The volatile parts are thus driven off, and the ore is prepared for farther analysis.

Vitrification is the fusion of such substances as are capable of assuming the brightness, transparency, and hardness of glass.

Stratification consists in arranging solid substances in layers, with intermediate *strata* of other substances, in order to expose them in a crucible to heat, so as to cause them to act upon each other, see page 74.

Granulation is employed for the mechanical division of some metals. It is performed either by stirring the melted metal with an iron rod until it cools, or by pouring it into water and stirring it continually, or by pouring it into a covered box, previously well rubbed with chalk, and agitating it until the metal cools, when the rolling motion will be converted into a rattling one. The adherent chalk is to be washed away.

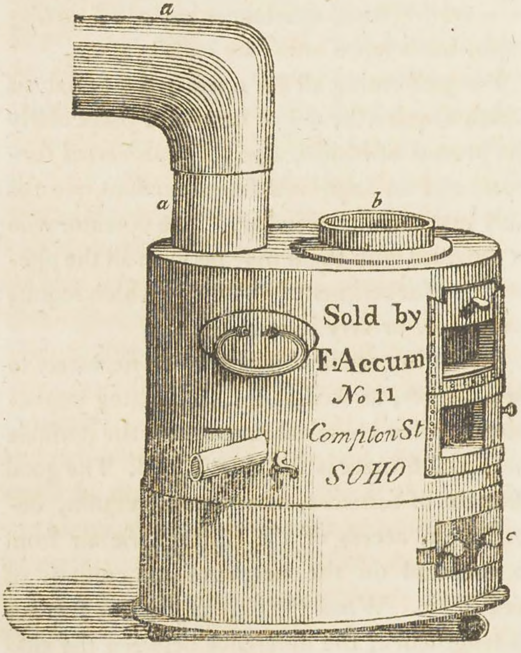
Fusion is the conversion of a solid into a liquid, by the application of heat. The substance thus rendered fluid, is said to be fused, or melted. A minute quantity of a substance may be fused by the flame of a candle, or lamp, urged by the *Blow-pipe.* The best blow-pipe is a conical tube, furnished with a small pipe near the base, to which jets or caps of different perforations may be adapted at pleasure. The air is either forced into the blow-pipe by the lungs of the operator, or by means of double bellows attached to the instrument. The substance to be fused must be placed upon a piece of charcoal, or held in a spoon, made of pure silver, gold, or platina. The quantity of the substance examined by the blow-pipe, should not exceed the size of a pepper-corn. If larger quantities of substances are intended to be fused, the vessels in which the operation is to be performed, are called *crucibles*, or *melting-pots*.

Crucibles are made of different materials. It is absolutely necessary to have a crucible of perfectly pure silver. Those of earthen-ware should be of various sizes and shapes. The larger are generally conical, with a small spout, for the convenience of pouring out the melted matters. The smaller crucibles are truncated triangular pyramids. Those known in commerce by the name of *Hessian crucibles* are in every respect superior to those manufactured in this country. The black-lead crucibles made of clay and black-lead are very durable, but they cannot be used for alcaline fluxes, or saline matters. Crucibles which ring clearly when struck, and which are of an uniform thickness, and have a reddish brown colour, without black spots, are the best; they should never be placed upon the grate of the furnace, but always on a piece of brick or other support of stone, or earthen-ware. When the fusion of a metallic substance is completed, the substance may either be permitted to cool in the crucible, or it may be poured into a heated mould anointed with tallow, (never with oil,) or what is still better, covered with a thin coating of chalk; which being previously diffused in water may be conveniently applied with a brush, and then evaporating the water completely by heating the mould. Conical moulds for receiving fused substances are called *casting cones*, bar-shaped ones, are called *ingots*.

For performing all the operations of analysis which require the aid of heat, and particularly the process of fusion, a *portable universal furnace*, and an *improved lamp-furnace*, are the only instruments necessary. The operator who is provided with them may perform all the operations of experimental chemistry which require a very low or very intense heat.

As an intense heat is very often necessary to fuse bodies, as well as for conducting conveniently other chemical operations, the portable universal furnace is the most useful. The good draught of furnaces, of any construction, depends on access of the atmospheric air from below, and on the height of the column of heated air. When the chimney of the furnace is lengthened, the difference between the specific gravity of the column of heated air which it contains, and the column of external air being greater, a larger quantity of fresh air is constantly forced through the fuel, and a strong draught, as it is termed, is formed.

PORTABLE UNIVERSAL FURNACE.



This portable universal furnace is made of strong wrought iron plates. It is lined with bricks, bedded in fire-proof loam. The height of this furnace without its chimney *a a* is two feet. The inner diameter of the cylindrical fire-place, measures 12 inches. The body of the furnace is eliptical; in its upper part a circular hole is cut, for receiving an iron sand-pot *b* which may occasionally be removed, and exchanged for an iron plate. In the front of the furnace there are three openings over each other, furnished with sliding doors, and fitted with stoppers made of crucible-ware. The lower opening *c*, is the ash-pit of the furnace; it is composed of two register plates, sliding backwards and forwards in groves, in order to diminish, or enlarge the opening for regulating the heat, by admitting or excluding air at pleasure. In the side of the furnace a hole is cut, furnished with a stopper and door, for passing a tube through the fire place of the furnace; an expedient very necessary for a variety of chemical processes, such as exhibiting the decomposition of water, alcohol, oils, &c. for the preparation of phosphuret of lime, for passing gases over ignited bodies, &c. In either of the openings in front of the furnace, muffle may be placed for performing the process of cupellation of gold, silver, &c. or, the neck of a retort (placed on a stand in the body of the furnace) may be passed through it, for distillation by the naked fire, for procuring gases which require a high degree of heat, &c. If the iron sand-pot *b* be removed, and a circular plate properly lined with fire clay be placed in its room, the furnace becomes converted into a wind-furnace; the fuel is then to be introduced through either of the openings in front. The iron plate at the top has a hole in the centre, furnished with a stopper, to enable the operator to inspect his process at pleasure. If the iron-pot be placed inverted on the opening of the furnace, it forms a dome, and the furnace becomes a reverberating furnace. The iron-pot when filled with sand, or water, placed in its proper situation, serves as a sand or water bath, for the processes of distillation by means of glass retorts, for evaporations, sublimations, digestions, &c. Coke and charcoal, are the best fuel: this mixture burns without smoke, and gives a strong uniform and permanent heat: charcoal and common coal, or coal only, does likewise very well. The elbow of the chimney *a* may be directed into that of the fire place of any apartment. The furnace is furnished with castors, and may therefore be easily moved according to the convenience of the operator. The great advantage of this portable universal furnace, above all others I am acquainted with, consits in consuming as little fuel as possible; in producing quickly if required an intense heat; in the power of applying it as directly and as fully as possible to the substance on which it is intended to act; in regulating expeditiously and at pleasure its intensity; in enabling the operator to perform any operation whatever which requires the aid of heat, and moreover in being able to perform these operations in the closet, or in any other place without risk of endangering the conflagration of the surrounding objects which were not meant to be exposed to the action of fire.

Lamp Furnace.—Where a moderate heat is required in the small way, the improved lamp-furnace, of which a drawing is given upon the title page, proves very useful. It consists of a brass rod about 3 feet high, screwed to a solid brass foot loaded with lead. On this rod slide three brass sockets, with straight arms, terminating into brass rings of different diameters, for supporting glass retorts, basons, flasks, crucibles, and for performing distillation, digestions, saline fusions, evaporations, &c. Each of these rings may by means of a steel thumb-screw acting on the brass socket, be set at different heights. Below these rings is a fountain lamp, on Argand's plan, sliding on the main brass rod, by means of a socket, and thumb-screw; and may therefore be elevated, or depressed, in order to communicate more or less heat to the vessel supported over it. This lamp-furnace may be taken to pieces, and packed in a small box.

Lutes also form a necessary part of chemical articles. They are compositions of various substances intended to close the joinings of vessels. Slips of bladder macerated in water, and applied with the inside next the vessels, are employed for securing the junctures of Retorts and Receivers. A paste formed of almond, or linseed meal, and glue dissolved in water forms an excellent lute for similar purposes. Quicklime reduced to powder beat up × with white of egg, (diluted with a little water,) and retained by slips of linen, dries quickly, and becomes very hard, which renders it an

× Qu. if? then beat up quick-L and fresh-useful lute for the distillation of acids. The lutes employed for coating glass vessels, with the intention of making them stronger and capable of resisting a sudden and violent heat, without softening; consists of four parts of fine sifted sand, and one of clay, made into a very thin mass, and applied in successive layers, taking care that each coat be perfectly dry, before another be laid on.

In the conducting of experiments, I cannot recommend better general rules, than those advanced by Mr. Henry, in his valuable Epitome of Chemistry, p. 2, namely; let every jar or phial have a label affixed to it, denoting the substance it may contain, (except in cases where the nature of the contents is evident from mere inspection,) and the date and object of the experiment. I would caution the student not to engage in many different experiments at once; the consequences of which are, that the attention is distracted, and that many interesting changes pass unnoticed. It will contribute to form a habit of accurate observation if the appearances that occur in experiments be regularly and distinctly noted down; and such an exercise will tend also to facilitate the acquirement of the art of describing chemical phenomena; to do which, with selection and precision is very far from being an universal talent.

The analyst ought likewise to be provided with a few other utensils, namely; a spirit-lamp, glass funnels, glass rods for stirring acid and corrosive mixtures, tumblers, wine glasses, apothecaries phials, Florence flasks, glass-spoons, conical glasses, the inside of which terminate in an oval bottom, for putting a small piece of a mineral in to try the action of acids upon it, and a complete collection of chemical

RE-AGENTS, OR TESTS.

Besides the instruments before enumerated, the operator has occasion for a great variety of materials made use of as active means for performing his examinations. These substances are called chemical Re-agents or Tests, (see page 3). That we may depend on the results which these bodies offer it is absolutely necessary that they should be in a state of possible purity. The following is a compleat collection of chemical tests, and other articles necessary for the analysis of minerals.

LIST OF CHEMICAL RE-AGENTS, OR TESTS.

Sulphuric acid
Nitric acid
Muriatic acid
Nitro-muriatic acid
Oxigenized muriatic acid
Phosphoric acid
Acetous acid
Tartareous acid
Boracic acid
Chrystallized Potash
———— Soda
———— Barytes
Liquid ammonia
Carbonate of Potash
Carbonate of soda freed from its water of crystallization
Muriate of Tin
———— Platina
Muriate of Gold
———— Barytes
———— Mercury
———— Ammonia
Nitrate of Lead
———— Mercury
———— Silver
———— Potash
———— Barytes
Barytic water
Sulphate of Potash
———— Soda
———— Iron
Alcohol
Tincture of Galls
———— Turmeric
———— Litmus
Prussiate of Potash
Black Flux

White Flux
Oxalate of ammonia
Fluate of ammonia
Acetite of Silver
Hydro-sulphuret of ammonia
Phosphate of soda and ammonia
Cylinders of Copper
——— Tin
——— Zinc
——— Iron

A select collection of CHEMICAL RE-AGENTS *prepared with the most scrupulous accuracy under the direction, and in the Laboratory of the Author, together with all the necessary* APPARATUS *and* INSTRUMENTS, *for performing the different analysis enumerated in this Essay, as well as for analysing mineral substances in general, may be had as a companion to this Essay, forming a neat* PORTABLE MINERALOGICAL LABORATORY.

GENERAL
CLASSIFICATION
OF
MINERALS.

If we contemplate the solid parts of this globe, we behold an immense assemblage of a vast variety of heterogeneous bodies. We perceive it to be arranged with an irregularity of distribution, which may well excite our surprize, and arrest our attention. Stones, metallic substances, inflammable fossils, saline bodies, either in lapideous or in metallic aggregation, or else in a state of comminution, are the only proper component parts of the whole. But in order to arrange our examination of these substances with greater precision, as well as to facilitate the primary knowledge of minerals in general, mineralogists have divided them into four general classes, distinguishable from each other, by very obvious and permanent characters.

Whatever division we may adopt or frame, it is enough that the classification should be so made that minerals which possess some general, obvious, or physical properties should be arranged together, in order to form a certain system or methodical arrangement, namely:

Class. I. ORES
II. EARTHS AND STONES
III. MINERAL OR NATIVE SALTS.
IV. INFLAMMABLE FOSSILS

This is the general division of minerals adopted by men of science. But as some of these classes present to us a vast variety of individuals of the same *species*, mineralogists have been under the necessity of sub-dividing them into certain genera and species, in order to remove, or at least to facilitate the numberless difficulties which would otherwise oppose the acquisition of general scientific knowledge. This will become more conspicuous in the sequel of this essay.

CLASS I.

ORES.

THE name of ORES, or metallic ores, as they are frequently called, is given to all those natural bodies, which are either entirely composed of metals, or of which metallic substances constitute the most considerable part. It is from this class of minerals that metals are obtained. The number of metals hitherto known amount to 23. It is obvious therefore, that the same number of different genera of ores must exist. Each of which is distinguished by the name of the particular metal, which forms its most essential part; namely,

ORES OF

Platina
Gold
Silver
Copper
Lead
Tin
Iron
Zinc
Mercury
Antimony
Bismuth
Nickel
Cobalt
Arsenic
Tungsten
Tellurium
Uranium
Molybdena
Chrome
Titanium
Manganese
Columbium
Tantalium

NATURAL HISTORY OF ORES.

All ores are found in the bowels of the earth, sometimes indeed at the surface, and more generally in mountains than in plain or level districts.

They are usually met with in crevices, or clefts of rocks, and are then called *veins*. These veins are generally deposited *upon*, or surrounded *by*, some stony substance, which is of a different nature from that of which the rock itself is composed. This substance whatever it may be, is called the MATRIX of the ore, which however must not be confounded with the mineralizing substance, with which the metal is combined, such as sulphur, arsenic, &c. for this latter is chemically combined with the metal, so as not to be separable but by chemical means, whereas the matrix may by separated by mechanical efforts. The veins of ores are always more or less inclined to the horizon, and hence they are distinguished by the name of direct, oblique, or inclined veins, according to the angle they make with the horizon. Thus placed by the hand of nature, they are more easily discoverd, than if situated on a level, or in plains.

CHARACTERISTIC PROPERTIES OF ORES.

Ores of metals may be distinguished from other minerals, by their greater specific gravity. They are at least five, six, or seven times heavier than water. All that is necessary to be done to distinguish metallic ores from other mineral substances is, to find their specific gravity, or in other words, to weigh them hydrostatically. This may be done in the following manner:

Let a piece of the mineral, *freed from its matrix* as much as possible, be suspended by a horse hair or thread of silk from the scale of a fine balance, weigh it in the air, and mark down its weight. Let it next, still suspended from the balance, be immersed in a glass of water, and ascertain how much it loses of its first weight in air, during the immersion in water, that is to say; how much weight is necessary to bring the scale to an equilibrium when the substance is suspended in water. Having done this, let the sum of the weight in air be divided by the sum of the weight which the body lost during its immersion in water, the quotient will then show the specific gravity of the mineral, for instance: suppose a piece of a mineral weighs in air 360 grains; but when immersed in water, loses 60 grains, the specific gravity of that mineral will be 6. for 360 divided by 60, is equal to 6. that is to say the mineral is 6 times heavier than water. It therefore contains some metal, and consequently belongs to that class of minerals called ores.

ANALYSIS OF ORES.

The variety of metallic ores being very great, no general method of analysing them can be given, which can possibly prove useful to those who are not skilled in chemical pursuits. The best method of acquiring that knowledge, consists therefore in examining the different genera of ores, one by one, in order to acquire a summary knowledge of those generalities which have been deduced from the analytical labours of former philosophers, and to become familiar with certain general principles, and manipulations, which characterize, and are requisite for the analysis of each individual.

ORE OF PLATINA.

Hitherto no ore of Platina has been discovered. The Platina we meet with in the cabinets of mineralogists, is however considered by some as the ore of this metal. It is found interspersed among the auriferous sands of certain rivers. It always contains more or less iron; sometimes also a small quantity of mercury adheres to it, arising from the amalgamation which it has undergone, in extracting the gold. There are no different varieties of platina known yet. Platina of commerce exists in small flat grains of a grey white colour. It is by far the heaviest body known in nature. Its specific gravity being from 21.061, to 23.

ANALYSIS OF GOLD ORES.

Gold, the most precious of all metals, is hitherto found only in a metallic state, generally alloyed with other metals. Its matrix is most commonly quartz. It has however been met with in lime-stone, and in silicious schistus.

The different varieties of gold ores are distinguished from each other, according to the different shapes in which the gold is found to exist in them, hence the denominations of *gold in filaments*, or *filamentous gold ore*, *dendritical gold*, *lamellated*, *arborescent*, *wire-shaped gold*, *&c.* Gold is also met with in a metallic state, intermingled amongst the sands of certain rivers. It is then called *gold dust*.

Native Gold.—There are two principle varieties of this ore, distinguished from each other, by the name of compact native gold, and crystalised native gold ore. The analysis of each of these ores, as well as those mentioned before, may be effected in the following manner:

Process I.—Take one part of the ore, freed as much as possible from its matrix, reduce it to a fine powder, put it into a Florence flask, and pour over it four parts of nitro-muriatic acid. Heat the mixture over a lamp, for at least half an hour, and renew the acid as it evaporates. Then suffer the whole to stand undisturbed, decant the supernatant fluid, dilute it with double its quantity of water, and filter it through paper.

II.—Affuse upon the insoluble residue in the flask, two parts of nitro-muriatic acid, and proceed as before. Mingle the decanted fluid with that obtained in the first process, wash the insoluble residue of the ore, by pouring a small quantity of water over it, and add this water to the before obtained nitro-muriatic solution.

III.—Transfer the fluid obtained in the foregoing processes into a Wedgwood's bason, and evaporate it slowly, over a lamp, to dryness.

IV.—Pour upon the residue, obtained in the last process, so much boiling distilled water as is sufficient to dissolve it, and filter the solution through paper placed in a funnel.

V.—Having done this, prepare a solution of green sulphate of iron, by dissolving one part of that salt in eight or ten of boiling water, and add so much of the solution to that obtained in process IV. till no farther change of color ensues, then suffer the whole to stand undisturbed for some days; the gold which was contained in the fluid will now be precipitated, and found at the bottom of the vessel, in the state of a brown powder.

VI.—Decant the fluid from this powder carefully, collect the latter, which is metallic gold, by putting it upon a filter, and when perfectly dry, introduce it into a crucible, and fuse it into a button or mass.

Remark—If the gold exists in the ore alloyed with a small portion of silver, a white powder will be seen floating in the nitro-muriatic solution: 100 parts of this powder when separated by the filter, and perfectly dried, contain 75 parts of silver, which may be obtained from it, as shall be noticed more fully under the article of silver ores.

If the ore contained copper, a polished cylinder of iron, after having been immersed in the nitro-muriatic solution, will be covered with a crust of copper, the increase of weight of the cylinder of iron gives us the quantity of copper. In this case the solution should have no excess of acid.

Gold Dust.—When gold is found interspersed amongst sand, or earthy substances, in the state of so minute particles, that it cannot be distinguished by the mere eye, we may for that purpose examine such substances, in the following manner:

Process I.—Diffuse the sand or earth through a large quantity of water in a convenient vessel, and frequently decant that fluid immediately after stirring it each time, by that means, the lighter particles of sand, or earth, as well as other substances, remaining longer suspended, may thus be washed away by the water employed, whilst the more ponderable particles of gold, fall to the bottom with greater rapidity.

II.—But as it would be difficult to separate the gold thus completely, by mere mechanical ablution with water, let the last portion of sand which has been repeatedly washed, be reduced to a very subtile powder, put it into a flask, cover it with nitro-muriatic acid, and digest it by heat for at least one hour, dilute the fluid with water, and separate the gold, by adding to it a solution of sulphate of iron, as directed, page 33, process V.

The presence of gold may be detected in an ore by effecting a solution of it in nitro-muriatic acid, and then letting fall into this solution a few drops of muriate of tin. If the minutest quantity of gold be present, a purple precipitate will instantly appear.

ANALYSIS OF SILVER ORES.

The varieties of silver ores are more numerous than those of gold, mineralogists have divided them into different species, according to their mineralising substance, which with the metal forms the ore; namely, *native silver*, or *silver in its metallic state*, ; nearly in a state of purity, *oxids of silver*, or silver combined with oxigen.

Sulphurated Silver Ores, or silver united to sulphur, and *salts of silver*, or silver mineralised by certain acids. As each of these different species of ores require different treatment, we shall consider them one by one in order to give an example of each of them.

Native Silver, or silver in a metallic state.

Process I.—Take one part of the ore reduced to a fine powder, affuse upon it in a Florence flask three or four parts of nitric acid, and apply a gentle heat; repeat this operation till a new addition of nitric acid does not produce any further action upon the residue, from which the acid has been decanted; having done this mix the different nitric solutions, pour over the insoluble residue a small quantity of water at a time, till this fluid runs off tasteless, then mix the water used for washing, with the first obtained nitric solutions.

II.—Add to the fluid obtained in the first process, common salt, dissolved in water, in small quantities at a time, till no farther precipitate ensues; collect this precipate, pour water over it so as to wash it thoroughly, then suffer it to dry. When perfectly dry, 100 parts contain 75 of silver which may be obtained from it in the following manner:

III.—Mix one part of the dry precipitate (muriate of silver) with three of carbonate of soda, freed from its water of crystallization, introduce this mixture into a crucible in the bottom of which a portion of the same salt has been put and pressed down; expose it in a fire to a red heat for half an hour, or till it fuses quietly. Then suffer the crucible to cool, and upon breaking it, a button of silver will be found at the bottom.

Plumbiferous Native Silver.—In this ore the silver exists alloyed with lead, and sometimes also with iron. The analysis of it may be accomplished in the following manner:

Process I.—Proceed as in the former process I, and immerse into the solution of the ore in nitric acid, a polished cylinder of copper, suffer the cylinder to continue in the solution for at least 24 hours. The silver will now be precipitated in a metallic state. It may be fused into a button without any addition, and its weight ascertained. It is essential however in this case that the solution of the ore should have no excess of acid.

II.—To the fluid from which the silver has thus been obtained, add a solution of sulphate of soda in water. If a white precipitate ensues it is a proof that lead was present in the ore. Its quantity may be determined by the weight of this precipitate; 100 parts of it when perfectly dry, indicate 30 of metallic lead.

III.—The presence of iron may be investigated by dropping into the solution, prussiate of potash, which in that case occasions a blue precipitate.

Auriferous Native Silver.—In this ore silver exists alloyed with gold. The analysis may be conducted thus:

Process I.—Let one part of the ore reduced to a fine powder be repeatedly digested in 3 of nitric acid, until the portion of the acid last decanted from the ore, does not yield any white precipitate, by dropping into it muriatic acid.

II.—Digest the insoluble residue in nitro-muriatic acid, till a new addition of that fluid extracts no more gold, which may be known by not becoming turbid, or letting fall a coloured precipitate, by adding to it a few drops of muriate of tin.

III.—To recover the gold contained in the last nitro-muriatic solution, proceed as mentioned before, page 33, process III. IV. V. &c.

IV.—The silver that was contained in the ore, and which is extracted in the first process by means of nitric acid, may be separated by precipitating it with muriatic acid, and subsequent reduction. See page 37.

Remark.—If the ore contains copper, as is the case in the ore called *cupriferous native silver ore,* the presence of this metal may be detected by dropping into the nitric solution, diluted liquid ammonia, the fluid will instantly acquire a blue hue.

Mercuriferous Native Silver, or native amalgam of silver, may easily be analysed, by inserting into a barometer tube closed at one end, a small quantity of the ore, placing the closed end which contains the ore, in a crucible filled with sand, and increasing the heat slowly, till the bottom of the tube is of a dull red heat. The quicksilver by these means will be volatilized or sublimed, in the upper part of the tube, and the silver will be left behind in a pure state. Instead of the barometer tube a small retort may be used, even with more advantage if the quantity of the ore exceeds at least ¼ of an ounce.

Sulphurated Silver Ore, or *Vitreous Silver Ore.*

Process I.—Let one part of the ore be digested in eight times its weight of nitric acid, of about 13.50, specific gravity, diluted with half its quantity of water, and repeat this operation till a new portion of acid, (after being suffered to act upon the ore for some time) does not become cloudy by the addition of a few drops of muriatic acid; then wash the residue, and add the water thus employed, to the nitric solution of the ore.

II.—In order to separate the silver from this solution, proceed as directed in the analysis of native silver ore, page 36 and 37.

III.—To ascertain the quantity of sulphur, which existed in the ore, take the insoluble residue of the first process dried thoroughly, put it into a crucible, and expose it to a red heat; the sulphur will take fire, and burn off. The loss of weight indicates the greater part of the sulphur. But in order to be more correct, pour water upon the residue left in the crucible, filter the fluid and drop into it a solution of nitrate of barytes, a white precipitate will fall down, collect it on a filter and dry it perfectly, 100 parts of this precipitate indicate 14. 5 of sulphur, which added to the loss of the weight the residue of the first process suffered, gives us the real quantity of the sulphur contained in the ore.

Remark.—The fluid obtained in process II. by decomposing the nitric solution of silver, by means of muriatic acid, should also be assayed for sulphuric acid, which perhaps may have been formed during the repeated action of the nitric acid upon the sulphur contained in the ore. If therefore a precipitate takes place on dropping into the above fluid nitrate of barytes, sulphuric acid has been produced; the precipitate must therefore be collected and weighed, and the quantity of sulphur calculated (as stated, in the preceding page,) and this quantity added to that already noticed.

Ruby Silver Ore may be analysed in a similar manner; for this ore differs from the latter merely by the presence of arsenic. This last substance may be discovered by adding to the nitric solution of the ore, from which the silver has been separated by muriatic acid, a solution of nitrate of lead, a precipitate ensues, 100 parts of which when perfectly dry, indicate about 22 of arsenic.

Pyritical Silver Ore, or Argentiferous martial Pyrites.—This ore which contains besides silver, also iron and sulphur, is best analysed in the following manner:

Process I.—Let one part of the ore be repeatedly digested in nitric acid, until all the silver is extracted, which may be known, by attending to the rules laid down, page 38, line 26, &c.

II.—To obtain the silver from the solution, immerse in it a cylinder of copper, and proceed as mentioned, page 38.

III.—To ascertain the quantity of iron and sulphur, let another portion of the ore be repeatedly digested in muriatic acid, till a few drops of prussiate of potash added to the last decanted solution, does not occasion a blue precipitate; the sulphur will be found floating upon the surface of the fluid, and may be separated by filtration.

IV.—To determine the quantity of iron, mingle the muriatic solution, with liquid ammonia, till no farther precipitate ensues, dry it, and expose it to a dull red heat for at least ½ hour.

Grey Silver Ore.—This ore is composed of silver, antimony, iron, sulphur, and sometimes copper and lead. Its analysis may be accomplished in the following manner:

Process I.—Let one part of finely pulverized ore be repeatedly digested in 3 parts of diluted nitric acid, till the acid takes up no more of the ore.

II.—Decompose the solution by the addition of common salt, or muriatic acid. (See process II. page 37,) collect the precipitate, and reduce it to its metallic state, as stated before.

III.—Let the solution from which the silver has been thus separated, be assayed for lead: for that purpose drop into it a solution of sulphate of soda, if a white precipitate ensues, lead was present in the ore. Its quantity may be ascertained by drying the precipitate and calculating the quantity of lead, as noticed already, page 38, process II.

IV.—After this add liquid ammonia to the solution till the odour of the former considerably predominates, a brownish precipitate will now be separated which is the iron that was contained in the ore; but in order to be certain that the precipitate consists of nothing but iron, proceed as follows:

V.—Let the precipitate obtained in the last process, be again dissolved in nitric acid; if it is not totally soluble in this fluid, the residue will be found to be silex.

VI.—To the last obtained solution add prussiate of potash till no farther precipitate ensues, and separate this blue precipitate by filtration.

VII.—To the filtered fluid, from which the blue precipitate (the precipitate of iron) has been separated by filtration, add now a solution of soda, if a precipitate falls down, it is alumine. Therefore after subtracting this earth, and the silex obtained in process V. from the weight of the brown precipitate obtained in process IV. the quantity of iron may be found.

VIII.—To the solution which had before been mingled with ammonia in excess (process IV.) add sulphuric acid, till it acquires a considerable acid taste, and immerse in it, a cylinder of iron; if the ore contained copper, this metal will be precipitated in a metallic state upon the surface of the iron cylinder.

IX.—Having thus far proceeded, take the insoluble part of the ore left in process I. digest it repeatedly in two or three parts of muriatic acid in a heat of ebulition, decant the fluid, and wash the residue in a little water, which add to the muriatic solution.

X.—To this muriatic solution add a large quantity of water; the precipitate which now falls down is oxid of antimony; 97 parts of which when dry, are equal to 75 of metallic antimony.

XI.—The insoluble part left behind in process I. which contains the sulphureous part of the ore, must be exposed in a crucible to a low red heat, and the quantity of sulphur determined, as shown, page 41.

XII.—The residuum left behind will then consist of silex only; it may therefore be fused with potash, and the earth precipitated by the addition of an acid, but this is no constituent part of the ore.

Light Grey and Dark Grey Silver Ores may be analysed in a like manner.

Bismuthic Silver Ore.—In this ore silver exists alloyed with bismuth and sulphur; it sometimes also contains a small quantity of lead, iron, and copper.

Process I.—Digest the ore repeatedly in nitric acid till this fluid exercises no farther action upon the ore.

II.—Pour the nitric solution into a large quantity of water, a precipitate falls down, which is oxid of bismuth; 123 parts of it when dry, are equivalent to 100 of bismuth.

III.—Evaporate the fluid to at least one-third of the original bulk, and then drop into it muriatic acid, collect the precipitate which falls down, wash, and dry it.

IV.—The precipitate now left is muriate of silver. Let it be digested in nitric acid, decant the fluid and mingle it with a large quantity of water, if any precipitate should ensue, it is a portion of oxid of bismuth which escaped the action of the water in process II. let it be dried and added to that obtained before.

V.—The remaining fluid may then be assayed for lead: let it therefore be concentrated, to dryness, dissolve the residue in a sufficient quantity of water, and drop into it sulphuric acid, a precipitate will appear, if lead be present, let it be collected and dryed, and the quantity of lead determined as stated, page 38, process II.

VI.—The solution from which the lead is separated may then be examined for iron; for that purpose add to it liquid ammonia, till the odour of the latter considerably predominates; a brown precipitate will fall down if iron was contained in the ore. This precipitate must be heated to redness and weighed.

VII.—If the ore contained copper, the fluid has now a blue colour, it may be saturated with sulphuric acid in excess. A cylinder of iron will precipitate the copper. See page 45, process VIII.

VIII.—The insoluble residue left in process I. may be examined for sulphur; for that purpose let it be ignited in a crucible, and proceed according to the rules mentioned, page 40.

IX.—The residue may again be digested repeatedly in muriatic acid, and assayed for lead, by sulphuric acid. If a precipitate ensues it is sulphate of lead, which is to be added to that obtained before. The residue left, if any, is merely the matrix of the ore.

Antimoniated Silver Ore.—This ore consists of silver, alloyed with antimony.

Process I.—Digest one part of the ore repeatedly in three of nitric acid, till a fresh portion of acid produces no further change on the residue.

II.—Separate the silver from this solution by copper. See page 38, process I.

III.—Digest the residue of process I. repeatedly in muriatic acid, till this acid extracts no more.

IV.—Pour the muriatic solution into a large quantity of water, collect the precipitate, which falls down and which is oxid of antimony. Its quantity may be calculated, as stated, page 45.

Calciform Silver Ore, or Red Silver Ore.—In this ore silver exists in the state of an oxid, combined with sulphur and oxid of antimony, and sometimes sulphuric acid. Its analysis may be accomplished thus;

Process I.—Let one part of the ore be repeatedly digested in 6 of diluted nitric acid, and filter the solution.

II.—Decompose this solution by adding to it muriatic acid, till no farther precipitate ensues: 100 parts of this precipitate, when perfectly dry, contain 75 parts of silver, and may be reduced to its metallic state as stated before, page 37, process III.

III.—Digest the insoluble residue in a similar manner in diluted nitro-muriatic acid. consisting of 5 parts of muriatic, and 1 of nitric acid. During this process, a powder separates and collects on the surface of the fluid, which is sulphur; let it be collected, dried, and its weight ascertained.

IV.—Dilute this fluid copiously with water, and a white precipitate will fall down, which is the oxid of antimony contained in the ore; let it therefore be dried and its weight noted. The quantity of metallic antimony it contains may be learnt, as stated before, page 45, process X.

V.—Let the fluid from which the antimony has been obtained, be mingled with that of process II. from which the silver has been separated by muriatic acid, and drop into it a solution of nitrate of barytes, a precipitate ensues, if the ore contains sulphuric acid: 100

parts of this precipitate when dry, are equal to 14.5 of sulphur.

Corneous Silver ore, or Native Luna Cornea (Horn Silver.) This ore is remarkable among the rarer ores of silver, not only on account of its richness, but likewise on account of the substance, by which nature has mineralized the silver in this ore; namely, muriatic acid, and sometimes also sulphuric acid.

Process I.—Take one part of the ore, mix it with 4 or 5 of carbonate of soda, put the mixture into a silver crucible, fuse it into an uniform mass, and suffer it to cool.

II.—Pour water into the crucible, and dissolve so much of the mass as is soluble, taking care to renew the water from time to time, till a new affusion of that fluid dissolves no more. Put this mixture aside for further investigaion.

III.—Digest the insoluble residue left in the last process, repeatedly, in nitric acid, till this fluid dissolves no more.

IV.—Decompose this nitric solution which contains the silver that was present in the ore, by adding to it gradually, muriatic acid in small quantities. The silver will thus be precipitated in the form of a white powder.

Every hundred parts of the precipitate, when perfectly dry, indicate 75 of metallic silver.

V.—Having thus ascertained the quantity of silver that was present in the ore, the insoluble residue which was not acted upon by nitric acid, may be digested in nitro-muriatic acid, in order to take up the iron, if any be present in the ore. To separate this metal add liquid ammonia, collect the precipitate, dry, ignite, and weigh it.

VI.—Mingle the solution of process II. with acetous acid, adding the latter in small quantities at a time, until no further effervescence ensues. The mixture will now be rendered turbid, and a precipitate will gradually be deposited, which is the alumine that was contained in the ore: its weight may be ascertained after having been dried and ignited.

VII.—The fluid from which the alumine has been separated must then be evaporated to dryness, and alcohol affused upon it in a phial, so as to cover it at least one inch high, agitate the whole frequently during the space of 3 or 4 days, and then decant the alcohol. Transfer the salt left untouched by this fluid, on a filter and dry it. It is muriate of soda, originating from the muriatic acid contained in the ore, and the alkali made use of in process I. 116 parts of it are equal to 48 of muriatic acid.

VIII.—In order to learn whether any sulphuric acid was present in the ore, let this salt be dissolved in water, and drop into the solution muriate of barytes, if any sulphuric acid was present, a precipitate will ensue; this being collected and dried, gives the quantity of that acid contained in the ore, 100 parts of this precipitate contain 23.5 sulphuric acid, and 76.5 barytes.

ANALYSIS OF COPPER ORES.

Copper ores are divided into four classes: namely, ores containing copper in a metallic state, alloyed with other metals, but commonly called *native copper*. Ores containing copper mineralized by sulphur, or *sulphurets of copper*. Copper combined with oxigen, (oxids of copper,) or *calciform copper ores*, and salts of copper, or copper combined with acids.

Native Copper.—This ore frequently contains besides copper, a portion of gold, silver, and iron. It may be analysed thus:

Process I.—Let one part of finely pulverised ore be boiled in 4 or 5 times its weight of concentrated sulphuric acid to dryness.

II.—Upon the dry mass affuse about 8 times its quantity of water, boil the mixture for a quarter of an hour, and filter off the fluid.

III.—Immerse into this solution a polished cylinder of iron, the copper will be precipitated in a metallic state.

Remark.—If the ore contains gold, silver, and iron. It must be repeatedly digested in diluted nitric acid, the silver may be precipitated from this solution by a cylinder of copper, see page 38. The iron may be separated by evaporating the solution to dryness, dissolving it again in concentrated nitric acid, evaporating the acid as before, and repeating this operation for several times successively. This being done, let water be poured on the mass, and filter the solution. The iron will now remain upon the filter in the form of a brown powder, and the copper becomes dissolved in the watery fluid. This fluid may be decomposed by boiling it with potash, a precipitate is produced which is black oxid of copper, 100 parts of it after being dried in a red heat, contain 80 of copper. The ore called granular, or *cement copper*, may be annalysed in a similar manner.

Vitreous Copper Ore, or *Yellow Copper Ore*, (*Copper Pyrites.*)—This ore which is a sulphuret of copper, contains in general besides copper also iron.

Process I.—Digest one part of the pulverised ore, repeatedly in three times its weight of diluted nitric acid, till it extracts no more copper, which may be known by dropping into the last obtained solution, liquid ammonia. If the liquid acquires no blue colour, it has extracted no copper.

II.—Evaporate this solution to dryness, redissolve it in concentrated nitric acid, and again evaporate the solution to dryness: repeat this process for several times.

III.—Boil the dry mass in eight times its weight of water, a brown powder will become separated, which is the iron that was contained in the ore, collect it on a filter, wash, dry, and ignite it.

IV.—Mingle the fluid from which the iron has been separated, with a solution of carbonate of potash, till no farther precipitate ensues, collect the precipitate and dry it in a red heat, 100 parts then contain 80 of copper.

V.—To ascertain the quantity of sulphur contained in the ore, heat the residue of process I. and proceed as directed before; but as part of the sulphur is generally acidified during the digestion of the nitric acid upon the ore, the solution after the metal is separated may be assayed for sulphuric acid, by nitrate of barytes, and the real quantity of sulphur ascertained, according to the rule laid down, page 41.

The ore called purple copper ores, purple copper pyrites, variegated copper ore, or peacock's tail copper ore, may be analysed in a similar manner.

Grey Copper Ore, which, besides copper, sulphur, and iron, contains also silver, lead, and antimony, may be analysed in a like manner; the silver may be separated by common salt, (see page 37,) but as lead is also separated by this salt, the precipitate must be digested in liquid ammonia, this will dissolve the muriate of silver, and leave the lead, by subtracting the weight which the precipitate has lost by this treatment, the quantity of both the metals may be found. If antimony was present, it will be separated from the remaining solution by a copious affusion of water, the precipitate remaining insoluble by a still greater admixture of that fluid.

Oxids of Copper, or *Calciform Copper Ores*. (Red copper glass,) or red copper ore. This ore may be analysed by merely dissolving it in muriatic acid, and precipitating the copper by a cylinder of iron. The ores called *fibrous red copper*, and *tile, or brick red copper ore, copper malm*, all belong to this class, and may be examined in a like manner.

Green Carbonate of Copper, or *Malachite*.—The different varieties of ores, known by the names of *fibrous, radiated*, or *compact malachite*, as well as those distinguished by the appellation of *mountain green* and *mountain blue*, may be analysed in the following manner:

Process I.—In order to ascertain the quantity of carbonic acid, which in the ore exists united to the oxid of copper, let a portion of the ore be heated in a retort to a dull redness, collect the gas in the usual manner over mercury, and then let it be absorbed by lime water in order to measure its quantity; or if this should be deemed too troublesome, let one part of the ore be introduced into a bottle, containing 3 parts of sulphuric acid, diluted with 4 of water; close the bottle with a cork, into which is fixed a capillary tube, and weigh the whole accurately. When no more effervescence ensues, weigh the bottle and its contents; and the loss of weight will indicate the quantity of carbonic acid which escaped, with tollerable accuracy.

II.—To ascertain the quantity of copper, digest one part of the ore repeatedly in sulphuric acid, diluted with an equal bulk of water, till this acid extracts no more copper, (see page 54, process, I.) then filter the solution.

III.—Immerse into the sulphuric solution a cylinder of zinc or iron, and the copper will be precipitated.

The analysis of carbonates of copper may likewise be effected and perhaps more easily in the following manner:

Process I.—Take one part of the ore, expose it to a red heat in a crucible for about $\frac{1}{2}$ an hour.

II.—Let one part of this previously ignited ore be mixt with 3 times its quantity of black flux, and $\frac{1}{5}$ of charcoal powder, or resin, put the mixture into a crucible, cover it with a stratum of muriate of soda, and fuse it for about $\frac{1}{2}$ an hour, a button of copper will then be found when the crucible is broken.

Dr. Fordyce has given the following general process for analysing ALL copper ores.

Process I.—Take 100 grains of the pulverised ore, digest it repeatedly in one ounce of nitro-muriatic acid, composed of equal parts of nitrous, and muriatic acid, till all the copper is extricated, which may be known as directed already, page 54, process I.

II.—The different solutions are then to be mingled, precipitated by the addition of carbonate of potash, and the precipitate collected on a filter.

III.—This precipitate is to be re-dissolved in a sufficient quantity of sulphuric acid, and the solution precipitated by a polished cylinder of iron.

ANALYSIS OF LEAD ORES.

There are a vast variety of lead ores, which are classed by mineralogists into sulphurets, oxids of lead, and lead combined with different acids.

Sulphuret of lead, or galena, vulgarly called *potters-ore.* Ores of lead belonging to this class frequently contain a small quantity of silver, and sometimes also copper, and iron. We shall suppose all these metals to be contained in the ore, the analysis in that case ought to be conducted thus:

Process I—Let one part of the ore finely powdered, be very gently digested for at least 3 or 4 hours, in 6 of nitric acid diluted with about 3 or 4 of water, and repeat this process for several times sucsessively. During this process a great part of the sulphur contained in the ore will become separated in the form of a yellow powder floating on the top of the fluid.

II.—Add to the obtained solution, previously evaporated to a small compass, muriatic acid, till no further cloudiness appears; suffer the mixture to stand undisturbed, till the precipitate is fairly deposited, then decant or filter the fluid, separate the precipitate and wash it repeatedly, by pouring alcohol over it.

III.—The obtained precipitate consists of lead and silver, if the latter was contained in the ore.

IV.—In order to separate these two metals, digest the precipitate in liquid ammonia, for at least 24 hours, the silver will be dissolved and the lead left behind; or the muriate of lead may be separated by boiling the precipitate in a large quantity of water, which will dissolve the former, but leave the latter; but the first process is better.

V.—Evaporate the ammoniacal solution of silver, to dryness, and boil the residue in a solution of carbonate of soda; the product obtained is carbonate of silver, which may be reduced to the metallic state, by merely exposing it in a crucible to a red heat, or by re-dissolving it in nitric acid, and precipitating it by copper, see page 38, process I.

VI.—To ascertain the quantity of lead left behind in process IV. mix the muriate of lead with half its weight of black flux, introduce the mixture into a crucible, and expose it to a red heat, the lead will then be reduced to a metallic state, or this process may be omitted, and the quantity ascertained by merely weighing the dry precipitate, 100 parts of which contain 30 of metallic lead.

VII.—To find the quantity of sulphur, proceed as directed, page 41.

In order to assay the ore for iron, and copper, let the solutions, from which the lead and silver have been separated, be mingled with liquid ammonia, so that the latter is in excess, a brown precipitate will fall down which is an oxid of iron, (see page 47.) The presence of copper may be known by the solution acquiring a blue colour, by the addition of ammonia, and may be separated by immersing into the the fluid, after having been neutralized by sulphuric acid, a cylinder of zinc. All the different varieties of lead ores of this class may be analysed in a like manner.

Phosphate of Lead.—In this ore lead exists mineralized by phosphoric acid, in general contaminated with a portion of iron. It is found on the lead hills in Scotland, Germany, Carinthea, &c. Its colour is commonly green, yellowish green, or olive green. It is found stalactical and also of a regular shape. It is shining, semi-transparent, and gives a greenish trace. Its powder is yellowish. Before the blow-pipe it melts easily on charcoal, and assumes a crystalline form on cooling, by the addition of an alcali, the lead becomes in some measure reduced.

Process I.—Endeavour to effect a solution of this ore in boiling nitric acid, in the manner frequently stated before, and again evaporate to dryness.

II.—Dilute the mass with water till the crystals of nitrate of lead are dissolved,

III.—Saturate the solution with liquid ammonia, a precipitate ensues, which consists of lead and iron, if the latter existed in the ore. Collect the precipitate on a filter.

IV.—To separate these two metals boil the precipitate in muriatic acid to dryness, and pour alcohol on the dry mass, the muriate of iron will be dissolved and the lead left behind.

V.—Add concentrated sulphuric acid and apply heat, the muriatic acid will be expelled; weigh the precipitate, and, deducting 70 per cent. the remainder shows the quantity of lead.

VI.—Add lime-water to the solution from which the lead and iron have been separated, (process III.) the precipitate which appears, indicates the quantity of phosphate of lime.

ANALYSIS OF TIN ORES.

Tin ores are less numerous than either of the former, ores of gold excepted. Tin is found in two different states, namely; mineralized by oxigen, or oxids of tin; and mineralized by sulphur, or sulphurets of tin.

Native Oxid of Tin, or *Tin Stone.*

Process I.—Take one part of the ore, freed carefully from all its matrix, reduce it to an impalpable powder, triturate it with a like quantity of potash, and boil the mass in a silver vessel in 8 parts of water, evaporate the whole to dryness, and moderately ignite it for at least ½ an hour.

II.—Pour water upon the mass, boil the mixture for about a ¼ of an hour, and filter the fluid.

III.—Take the residue left on the filter, if any, mix it again with about 6 times its quantity of potash dissolved in a sufficient quantity of water, evaporate to dryness, and proceed as above.

IV.—Let the solutions thus obtained be mingled, and add to it muriatic acid, till no more precipitate falls down, adding the acid rather in excess; suffer the mixture to stand undisturbed till the precipitate is subsided, in order to collect it on a filter.

V.—Dissolve this precipitate in muriatic acid in excess, precipitate it again by the addition of carbonate of soda, collect the precipitate on a filter, wash it by pouring water over it repeatedly, and suffer it to dry.

VI.—Let the precipitate be again dissolved in muriatic acid, assisted by a gentle heat, (the insoluble part consists of silex) dilute the solution with 2 or 3 parts of water, immerse into it a cylinder of zinc: leave the whole undisturbed for some days, and all the tin that was contained in the ore will now be deposited round the cylinder of zinc in a metallic state. It may be formed into a button, by melting it in a crucible, taking care to cover it with charcoal powder.

The ores called wood-tin, needle tin, stream tin, hair-tin, and compact-tin, may be analysed in a similar manner.

Tin-Pyrites, or Sulphuret of Tin.—In this ore tin exists mineralized by sulphur, and frequently associated with copper; its analysis may be accomplished in the following manner:

Process I.—Let one part of finely pulverised ore be repeatedly digested in 6 of nitro-muriatic acid, composed of two parts of muriatic acid, and one of nitric acid, till it dissolves no more, and decant the fluid.

II. Add to this solution carbonate of potash, till no further precipitate ensues, collect the precipitate on a filter.

III.—Re-dissolve this precipitate in muriatic acid, diluted with 3 or 4 parts of water, and suspend in this solution a cylinder of tin, whose weight is known. If copper was contained in the ore it will be precipitated in a metallic state on the tin cylinder, but in order to be certain that it is not contaminated with tin, let the precipitated metal be re-dissolved by heat, in concentrated nitric acid; if a white powder remains it is a portion of oxid of tin.

IV.—But as in the foregoing process, the tin employed for precipitating the copper is acted upon by the muriatic acid, immerse into the solution from which the copper has been separated, a cylinder of zinc, the whole of the tin will be again precipitated on the cylinder of zinc; let it be dried and its weight ascertained, and melt it into a mass. From this quantity of tin, subtract now that portion which proceeds from the cylinder of tin employed for precipitating the copper, the remainder will give the true quantity of metal contained in the ore.

V.—Having thus far proceded, expose the insoluble residue left in process I. to a low red heat in a crucible, pour water into it, filter the fluid and ascertain the quantity of sulphur, as stated in the next page; what remains will be the matrix of the ore. It consists in general of alumine and silex.

ANALYSIS OF IRON ORES.

There are a vast variety of iron ores scattered over the surface of the earth, but they may nevertheless be divided into three general classes, namely; sulphurets, oxids, and salts of iron.

Sulphurets of Iron.—Martial pyrites, common sulphur pyrites, or mundick.

Process I.—Digest one part of the finely powdered ore in 3 or 4 of concentrated nitric acid, filter the solution, evaporate it to dryness, and repeat this operation at least 3 or 4 successive times.

II.—Pour four or five parts of muriatic acid upon the mass, and digest it till the whole is dissolved, taking care to supply the acid, from time to time as it evaporates.

III. To this solution add muriate of barytes till no farther precipitate ensues, filter the fluid, dry the precipitate completely, and weigh it accurately, 100 parts of it indicate 14.5 of sulphur.

IV.—The quantity of sulphur being thus found, we proceed to find that of iron; for that purpose let the solution obtained in process III. be mingled with a solution of soda, or potash, till no farther precipitate ensues; collect this precipitate, and expose it to a red heat in a crucible for ½ an hour: 100 parts of it then indicate 72 of iron, provided nothing else was contained in the solution; but as manganese and zinc have been found in this ore, it would be prudent to digest the precipitate in liquid ammonia, which will take up the zinc; the remainder may then be freed from manganese, by digestion in acetous acid, the oxid of iron will then be left behind; or the precipitate may be boiled in potash, which takes up the manganese, and leaves the iron behind.

The ores called *striated, capillary, mamillary, magnetical, hepatic,* or *liver pyrites, &c.* may be analysed in a similar manner.

Oxids of Iron, or *Calciform Iron Ores.*—The ores of iron belonging to this class, are uncommonly numerous, they however may be divided into two classes. Those namely in which the iron exists in the state of a black oxid, and these which contain it in a state of a red oxid. To the first class belongs the ore called,

Common Magnetic Iron Stone.

Process I.—Digest one part of the ore repeatedly in 6 of muriatic acid, till all the iron is extracted, which may be known when tincture of galls dropt into the fluid, which has been digested upon the ore, does not occasion a black precipitate.

II.—Decompose this solution by adding to it carbonate of potash, till no farther precipitate ensues.

III.—Let the precipitate be rapidly dissolved in nitrous acid, evaporate the solution to dryness, cover the residue with nitrous acid, evaporate it again, and repeat this process for several times successively.

IV.—Transfer the residue into diluted nitric acid, and digest it for one hour, dilute it with water, and filter off the fluid. The iron will be left on the filter, in the state of a red oxid; from the weight of this, after ignition for about one hour, 28 are to be deducted, the remainder gives the quantity of iron.

V.—As this ore seldom contains iron alone, but frequently also, copper, zinc, manganese, or alumine, let the solution from which the iron has been separated, be assayed for copper, by immersing into it a cylinder of iron; if copper be present it will be precipitated, the zinc may be separated by ammonia, and the manganese by acetous acid.

Micaceous iron ore, and Magnetic sand may be analysed in a similar manner.

Remark.—Should the ores of iron be found not readily soluble in muriatic acid, they should be mixt with $\frac{1}{8}$ of charcoal powder, and exposed in a crucible to a white heat for at least one hour.

The following class require particularly this previous treatment.

Hematites, or Blood Stone.—The iron ores belonging to this class, are very numerous.

The iron exists in all of them highly oxidised or in the state of a red oxid, more or less combined with clay, and sometimes manganese and lime. The principal ores of this kind are distinguished by the names of *compact iron ore,* or *red hematites; compact red fibrous* *hematites, brown hematites, brown scaly iron ore, red scaly iron ore, brown iron ochre, red iron ochre, black iron ore, common argillaceous iron ore, nodular,* or *kidney-shaped iron ore, Ætites, or Eagle stone, pisic form, or granular iron ore.* The analysis of all these ores may be accomplished in the following manner:

Process I.—Let one part of the finely powdered ore be mingled with $\frac{1}{8}$ of charcoal powder, or lamp black, introduce the mixture into a crucible to which a cover has been luted, and expose it to a white heat for at least one hour.

II.—Put the ore thus partly de-oxidised, into a flask, and endeavour to effect a solution, by digesting it repeatedly in 3 parts of concentrated muriatic acid, till this fluid ceases to act upon it any longer.

III.—Dry the insoluble residue, mix it again with about $\frac{1}{8}$ of charcoal, and proceed as before; digest it again in muriatic acid, till all the iron is totally extracted.

IV.—Mingle the different solutions, add 10 or 12 times their bulk of boiling water, and preserve it in a stopt bottle for some weeks; the phosphate of iron (siderite) if any was contained in the ore will then be precipitated; in that case decant the fluid.

V.—Having done this, precipitate the decanted fluid by carbonate of soda, which will separate not only the iron, but also all the earths that were dissolved by the acid. To separate these, follow the rules laid down under the class of earths.

Remark.—Rinman assures us that the quantity of iron in an ore, containing no visible heterogenous matter may be estimated pretty accurately, by dividing its specific gravity stated in integral numbers by 80. Thus an ore whose specific gravity was 3.893 gave $\frac{3893}{80}$— 48.6, and in reality contained 50 per cent. of iron. The error was only 1.5 per cent.. However this holds good only with respect to ores whose specific gravity exceeds 3.6 ; when less 150 should be the divisor, the error still will be 15, or 2 per cent.

ANALYSIS OF ORES OF ZINC.

There are three general species of zinc ores, namely, sulphurets of zinc, oxids, and zinc in the saline state, or combined with acids.

Sulphuret of Zinc, or *Blende*—There are a great many varieties of this genus of ore, generally distinguished from each other by the colour only; namely, yellow, brown, black, red blende. In these species of ores zinc is combined with sulphur, iron, and sometimes copper. They may be analysed in the following manner:

Process I.—Take one part of the ore reduced to powder, digest it repeatedly in 4 parts of diluted nitric acid, and repeat this operation till the acid does not produce any farther action on the residue.

II.—Mingle the different solutions, evaporate the whole to dryness, repeat the evaporation and affusion of nitric acid successively for several times; lastly, suffer the nitric solution to stand undisturbed, and decant the fluid from the insoluble residue. If there was any iron in the ore it will remain behind in the form of a brown powder, together with the alumine, which was contained in the ore.

III.—Decompose the nitric solution by adding to it a solution of soda, collect the precipitate, and wash it.

IV.—Re-dissolve this precipitate in muriatic acid, and assay the solution for copper, by immersing into it a cylinder of iron, for in that case copper will be precipitated. If not, saturate the solution with liquid ammonia, and add this fluid in excess, if a red precipitate ensues it is iron, which escaped the action of the nitric acid, in the last process, add it therefore to that obtained before. The zinc now remains in solution.

V.—To separate the zinc, saturate the solution with muriatic acid, the precipitate which falls down, is oxid of zinc, it may be reduced to the metallic state, by strongly igniting it with half its weight of charcoal in a closed crucible.

VI.—In order to ascertain the quantity of alumine and iron, which was contained in the ore, (process II.) boil it in a concentrated solution of potash, the alumine will be dissolved and the oxid of iron left behind.

VII. To determine the quantity of sulphur, treat the insoluble residue as described, p. 40, process III. and page 41.

Common Calamine, or *oxid of Zinc, combined with carbonic acid,* may be analysed in a similar manner.

Process I.—Digest the ore as above directed repeatedly in nitric acid.

II.—Treat the insoluble residue in a similar manner with muriatic acid.

III.—Evaporate the nitric solution to dryness, it contains the zinc, and probably only iron and alumine.

IV.—Re-dissolve the mass in liquid ammonia in excess, and proceed as directed before.

V.—The muriatic solution, (process II.) frequently contains also iron and alumine, which may be separated by decomposing the solution by potash, and proceeding as above.

Remark.—A tolerable exact essay of calamines, or oxids of zinc combined with carbonic acid, in respect to its contents of zinc, may be made in the following manner:

Mix any quantity of pulverized ore, previously freed from sulphur by roasting, with $\frac{1}{6}$ part of charcoal powder. Put this mixture into a capacious crucible, and diffuse equally amongst it a quantity of granulated copper, or thin plates of that metal, equal in weight to that of the calamine employed, and upon the whole lay another equal quantity of copper, and lastly cover this latter portion with a stratum of charcoal powder, lute a cover to the crucible, and apply a red heat for one or two hours. The volatilized zinc will thus combine with the copper and convert it into brass. By comparing the weight of the metal after the operation with the weight of the copper employed, the quantity of zinc united with the copper will be known. The copper which has not been converted into brass, or more copper with fresh charcoal powder may be again added in the same manner to the remaining ore, and the operation repeated with a heat somewhat more intense, in order that any zinc remaining in the ore may be extracted. The ores called friable calamine, compact calamine, lapis calaminaris, striated calamine, or zinc spar, may be analysed in a similar manner.

ANALYSIS OF ORES OF MERCURY.

Mercurial ores are divided into alloys, (or mercury in a pure state, or nearly so,) commonly called *native*, or *virgin mercury*; sulphurets of mercury, or native cinnabars, and mercurial salts, or mercury mineralised by different acids.

Mercury alloyed with Silver.—The analysis of this ore has been mentioned already, (page 39.) If it should contain beside silver, bismuth also, the following method may be had recourse to.

Process I.—Dissolve the amalgam in nitric acid.

II.—Precipitate the bismuth by adding to the solution, a considerable quantity of water, collect the precipitate and dry it, 123 parts of this oxid are equal to 100 of metallic bismuth.

III.—To the solution from which the bismuth has been separated, add muriatic acid, and collect the precipitate which falls down.

IV.—To separate the two metals transfer the precipitate into liquid oxigenized muriatic acid, or boil it in a large quantity of water, in both cases the muriate of mercury will be dissolved, and the muriate of silver remain behind.

V.—To reduce the silver, proceed as stated page 37, process III.

VI.—To separate the mercury mingle the solution with sulphate of iron, dissolved in water, and collect the precipitate.

Sulphuret of Mercury, or Cinnabar. The ores of mercury belonging to this class are best analysed by distilling a mixture made up of three parts of the ore, and one of lime, or iron filings in a strong red heat, adapting to the stone retort a receiver filled with water, into which the neck of the retort is kept immersed during the distillation.

ANALYSIS OF ORES OF ANTIMONY.

Antimony is found in nature mineralized by sulphur, forming the ores called sulphurets of antimony, or combined with oxigen, as *antimonial ochres;* when alloyed with other metals, it is called *native antimony*, and in the state of a salt it constitutes muriate of antimony.

Sulphuret of Antimony.

Process I.—Let one part of finely pulverised ore be repeatedly digested by heat, in four parts of nitro-muriatic acid, composed of three or four of muriatic, and one of nitric acid, till it exercises no farther action upon the residue. The sulphur contained in the ore will remain behind, and may be investigated, as stated page 40, process III. and page 41.

II.—Pour the filtered solution into a large quantity of water, the precipitate which falls down is oxid of antimony, collect it on a filter and weigh it: 97 parts when perfectly dry, are equal to 75 of metallic antimony. It may be reduced by mixing it with double its weight of charcoal powder, and subsequent fusion.

III.—But as lead and iron are in general contained in the ore, as is the case in that species called yellow antimoniacal ore; let the solution from which the antimony has been separated, be concentrated by evaporation. If a precipitate of oxid of antimony appears, during this process, collect it, and add it to that obtained before; then drop into the fluid, a solution of sulphate of potash, or sulphuric acid, if lead was present a white precipitate will appear, see page 38, process II.

IV.—If iron be present, a brown precipitate falls down on the addition of liquid ammonia. See page 47, process VI.

The ores of antimony called compact, foliated, striated, iridescent, or variegated sulphurated antimony, may be analysed in the same manner.

Argentiferous antimony differs from the former by containing a portion of silver. It may be examined thus:

Process I.—Digest a determined quantity of the ore in nitric acid by heat, until a portion of acid added a fresh does not produce any farther solution, dilute the fluid with water and filter it.

II.—Immerse into this solution a cylinder of copper, the silver will be separated. See page 38, process I.

III.—Upon the residue left in proceess I. pour muriatic acid, and proceed as before, till a new addition of acid dissolves no more.

IV.—Pour the muriatic solution into a large quantity of water, and collect the precipitate which is oxid of antimony. See page 78.

Native Oxids of antimony, or *antimonial ochres,* are best analysed by dissolving them in nitro-muriatic acid, and subsequent dilution with water, and proceeding as before.

ANALYSIS OF ORES OF BISMUTH.

Bismuth exists in nature in a native state. Ores of that kind are called native bismuth. It is also found combined with oxigen, forming oxids of bismuth, or bismuth ochres. Mineralized by sulphur, it constitutes sulphurets of bismuth.

Native Bismuth may be analysed in this manner:

Process I.—Digest a determinate quantity of finely pulverised ore repeatedly in nitric acid, assisted by heat, till the fluid dissolves no more, which may be known by the last portion of acid occasioning no precipitate, when mixed with water.

II.—To separate the bismuth from the solution, mingle it with a large portion of water, a white precipitate falls down, which is oxid of bismuth: if the whole should not be separated at first, let the solution be concentrated by evaporation, a second affusion of water will then precipitate the remainder.

III.—To reduce this oxid to the metallic state, form it into a paste with a few drops of oil, and fuse it rapidly with one-third of its weight of black flux.

IV.—To ascertain the quantity of sulphur, treat the insoluble residue of process I. as directed, page 40 and 41.

The rest of the ores of bismuth may be analysed in a similar manner.

ANALYSIS OF ORES OF NICKEL.

The most abundant ores of nickel are that species called sulphurets of nickel, or kupfernickel. In this ore nickel is combined in general with arsenic, sulphuret of iron, and sometimes cobalt and copper. The rest of the ores of this metal are those called oxids, or nickel ochres; and salts of nickel, or nickel mineralised by acids.

Sulphuret of Nickel, or *Kupfernickel.*

Process I.—Let any quantity of the ore, finely pulverised, be first roasted, in contact with charcoal powder, over a gentle heat, and digest it repeatedly in nitric acid, as long as this fluid takes up any part of the ore; filter the different portions of acid employed, wash the residue, and mingle the whole.

II.—Pour the before-obtained solutions of the ore into a large quantity of water, a milkiness will now ensue. Suffer the whole to stand undisturbed, in order that the precipitate may be allowed to subside, which must then be collected and dried.

This is the arsenic which was contained in the ore; but as it is probable that a part of this substance still remains in the solution, it may be separated as follows:

III.—Concentrate the solution from which the arsenic has been partly separated, to a small compass, and add a boiling solution of carbonate of potash in excess; if it contained arsenic it will become separated.

IV.—Transfer this precipitate into a flask, containing acetous acid, and affect a solution with heat.

V.—Mingle this solution with liquid ammonia in considerable excess, a brown precipitate falls down, which is the iron contained in the ore, and the oxid of nickel and cobalt remain dissolved.

VI.—Having so far proceeded, evaporate the solution slowly, a precipitate falls down, which is oxid of cobalt; and on continuing the evaporation gradually to dryness, the nickel which was contained in the ore is obtained, after heating the dry mass, till the nitrate of ammonia is decomposed.

VII.—In order to reduce this oxid to the metallic state, let it be made into a paste with oil, mix it with about 3 parts of black flux, put it into a crucible, cover it with common salt, or borax, and heat the crucible violently for 2 or 3 hours.

VII.—To ascertain the quantity of sulphur, treat the residue of the first process, as directed page 40 and 41.

Arseniate of Nickel requires a treatment a little different from this.

Process I.—Let one part of the ore, finely pulverised, be boiled with 3 of potash, in 6 of water, for at least one hour, supplying this fluid as it evaporates, and lastly evaporate it to dryness.

II.—Pour water upon the mass, suffer the insoluble part to subside, filter off the fluid, and wash the residue repeatedly, by passing water over it, and then proceed, as in the last analysis.

Oxids of Nickel may be treated in a similar manner.

ANALYSIS OF ORES OF COBALT.

Cobalt ores are divided into sulphurets, oxids, alloys, and salts of cobalt.

Sulphuret of cobalt, or *White Cobalt ore.*—This ore in general contains, besides cobalt, also iron, and sometimes arsenic.

Process I.—Take one part of the ore, reduced to a fine powder, pour over it 3 or 4 parts of diluted nitric acid, assist its action by heat; repeat this operation successively, or till the acid does not exercise any action upon the ore; then dilute the solution with double its quantity of water, and filter it.

II.—Drop into the solution carbonate of potash, dissolved in water, till no further precipitate ensues: collect the precipitate, wash and dry it; it consists of iron, cobalt, and arsenic. The solution may probably contain a portion of arseniate of potash, originating from a part of the arsenic being acidified during the process. The arsenic may be separated by heat, if it contained any.

III.—Dissolve the precipitate in acetous acid, evaporate the solution slowly to dryness, repeat this operation two or three times, lastly pour acetous acid over it, and digest it for about half an hour, and then filter the fluid; by this means the iron will become separated, and the cobalt remain in solution.

IV.—Drop into this solution liquid ammonia, a precipitate will first ensue, but on adding more ammonia the precipitate will again become re-dissolved.

V.—Evaporate the ammoniacal solution to dryness, the cobalt will be obtained in the state of an oxid. In order to reduce it to its metallic state, mix it with two or three parts of black flux, and one of borax, and expose it to a violent heat for at least an hour.

VI.—To ascertain the quantity of sulphur, treat the insoluble residue according to the rules laid down, page 41.

The ores called grey cobalt, compact and bright grey cobalt ore, may be examined in a like manner.

ANALYSIS OF ORES OF ARSENIC.

Arsenical ores are divided into three different species, namely; native arsenic, or arsenic in a metallic state; sulphurets of arsenic, or arsenic combined with sulphur; and oxids of arsenic, or arsenic mineralised by oxigen.

Native Arsenic, Arsenical Pyrites, Marcasite, or *Irish Diamond.*—In this ore arsenic is sometimes alloyed with a small portion of silver, gold, or iron. The analysis may be accomplished in this manner:

Process I.—Take one part of the finely pulverised ore, digest it repeatedly, assisted by heat, in three of nitro-muriatic acid, composed of one part of nitric and one and a half of muriatic acid, and repeat this operation till a complete solution is obtained, or till a new portion of acid produces no further action upon the residue; then decant the fluid, and let it subside. If a white precipitate be observed in the fluid, the ore contained silver, (as is the case in the ore called Argentiferous Arsenical Pyrites); let the precipitate be therefore collected. It is muriate of silver. See page 34.

II.—Evaporate the nitro-muriatic solution, from which the silver has been separated, to about $\frac{1}{4}$, and add to it water, till this fluid occasions no further turbidness, which may be known by filtering from time to time a small quantity of the mixture, and assaying the filtered solution by a new addition of water. The white precipitate obtained is oxid of arsenic.

III.—Re-dissolve this precipitate in muriatic acid, and precipitate it, by immersing into this solution a plate of zinc, mixing with it at the same time $\frac{1}{10}$ part of alcohol; this precipitate, after being dried, may be reduced to its metallic state, by exposing it in a covered crucible to a moderate heat.

IV.—The solution, from which the arsenic has been separated, may be assayed for iron: for that purpose, let it be concentrated, and mix it with liquid ammonia in excess; if a brown precipitate ensues, it is iron.

Remark.—If the ore contain gold, nitric acid should be made use of in the first process. The residue may then be treated in a similar manner with nitro-muriatic acid, and the solution precipitated by sulphate of iron.

Sulphuret of Arsenic.—Of this ore there are two species, namely; yellow sulphurised arsenic, or orpiment; and red sulphurised arsenic, re-alger, or ruby aresnic. The analysis of both these ores may be accomplished in a similar manner: in that case the insoluble residue of the first process contains the sulphur of the ore, the quantity of which may be found according to the rules laid down, so often before.

Native Oxid of Arsenic, which is very scarce, may be analysed, by dissolving it in muriatic acid, precipitating the solution by water, and subsequent reduction of the precipitate, as stated in the opposite page.

ANALYSIS OF ORES OF TUNGSTEN.

There are only a few ores of tungsten known, namely; wolfram, or more properly tungstate of iron and manganese, and tungstate of lime; of the latter there are some varieties.

Wolfram, or *Tungstate of Iron and Manganese*, may be analysed thus:

Process I.—Take one part of the ore, finely livigated, digest it in a gentle heat for at least an hour, in 3 parts of muriatic acid; suffer it to cool, decant the solution, and wash the residue repeatedly in as little water as possible.

II.—Pour over the residue two parts of liquid ammonia, suffer it to stand for some days, and agitate it frequently; decant the ammoniacal solution, wash the residue, and digest it alternately in muriatic acid and in ammonia, until it experiences no farther diminution, or till the whole is nearly, or totally dissolved.

III.—Mingle the ammoniacal solutions, and evaporate it in a retort or bason, to dryness; transfer the mass into a crucible, and heat it thoroughly, or till it acquires a yellow colour. This product is the oxid, or acid of tungsten.

IV.—Having done this, mix all the muriatic solutions which contain the iron and manganese, with $\frac{1}{6}$ part of sulphuric acid, and evaporate the whole to dryness.

V.—Re-dissolve the before obtained mass in water, and add to it a solution of carbonate of potash, the precipitate which falls down consists of the iron and manganese, contained in the ore; collect, wash, and dry it.

VI—To separate these metals, digest the precipitate by heat repeatedly in nitric acid, and evaporate it to dryness.

VII.—Transfer the mass into acetic acid, and digest it with heat; the manganese will then become dissolved, and the iron remain behind, deducting the weight of this, from the weight of the whole precipitate, the respective proportions of each may be found; or if a solution of an alkali be added, the liquor will assume a brown colour, and a precipitate will be obtained after boiling the fluid for a few minutes. This is the manganese contained in the ore.

Tungstate of Lime.—In this ore tungsten exists combined with lime.

Process I.—Digest one part of the ore repeatedly in 3 of nitro-muriatic acid, till a new addition of acid, dissolves no more. The earth will be dissolved, and the tungsten remain behind in the form of a yellow oxid; if pure, it is soluble in liquid ammonia, from which it may be recovered, as directed in the preceding analysis.

II. The muriatic solution contains the lime, and sometimes a little iron; on adding to it carbonate of potash, the lime will be precipitated: if it contains iron, dissolve the precipitate in muriatic acid, and add liquid ammonia, the iron will thus become separated.

ANALYSIS OF ORES OF TELLURIUM.

There are only three different ores containing tellurium hitherto known: in all of them tellurium is alloyed with other metallic substances, namely; in the white gold ore of Fatzebay, which is likewise called aurum paradoxum, tellurium exists combined with iron and gold. In the ore called graphic gold, tellurium is alloyed with gold and silver, and sometimes also with lead; and in the ore called gray foliated gold ore of Naggag, tellurium is united to gold, lead, silver, copper, and sulphur.

White Gold Ore of Fatzebay.

Process I.—Let one part of the finely pulverised ore be gently boiled with six parts of muriatic acid, and then add three parts of nitric acid gradually. Repeat this operation till the acid exercises no farther action upon the ore, and filter the solution.

II.—Dilute it with so much water as it can bear, without becoming turbid, and add to the solution potash, dissolved in water, in excess, or until the white precipitate which is first formed, is again dissolved, and nothing remains but a brown flaky sediment, which is a mixture of gold and iron contained in the ore.

III.—To separate these two metals, let it be re-dissolved in nitro-muriatic acid, precipitate the gold from this fluid by a solution of nitrate of mercury, and the iron by potash. The mercury may be separated by heating the precipitate to redness.

IV.—To the alcaline fluid of process II. add muriatic acid, taking care to avoid an excess of acid. The oxid of tellurium is thus precipitated in the form of a white oxid.

V.—To reduce this oxid to the metallic state, form it into a paste with a small quantity of oil, and put it into a retort, or crucible:

as the oil becomes decomposed, brilliant and metallic drops are observed in the upper part of the vessel, which increase in number until the oxid is reduced.

All the other ores may be analysed in the same manner, with the only difference that the precipitate produced by the potash, must be treated according to the metals of which it consists, namely; if it contains silver, as is the case in the graphic gold ore, the silver will be separated in the form of white flakes, lead may be detected by sulphate of soda, (see page 38,) and copper by polished cylinders of iron.

ANALYSIS OF ORES OF URANIUM.

Uranium is found in nature in the state of an oxid, the oxid of uranium exists combined with a greater or smaller portion of iron, lead, and sulphur: it forms the ore called pitch-blende, or oxid of uranium; combined with carbonic acid, it forms the mineral, called chalcolite.

Uranium, or *Pitch-blende.*

Process I.—Take one part of the ore finely pulverised, digest it repeatedly in 4 parts of diluted nitric acid, till nearly the whole of the ore is dissolved, or till a new portion of acid occasions no farther action upon the residue; the black colour of the ore shows that its decomposition is complete.

II.—Evaporate the solution to at least one third of its original bulk, and leave it to cool, a precipitate will become deposited, which is nitrate of lead, collect it by filtration. To ascertain the quantity of lead, add sulphuric acid, and proceed as directed, page 38.

To separate a small portion of iron which is generally dissolved by the acid, immerse a cylinder of zinc into the solution, the iron will become precipitated.

III.—Into the nitric solution from which the lead has been separated, let fall a solution of potash, the precipitate which is formed consists of oxid of uranium and oxid of zinc.

IV.—To separate these two metallic oxids, transfer the precipitate into a phial containing liquid ammonia, and digest for some days, the oxid of zinc will become dissolved in the ammonia, and the oxid of uranium left behind: transfer it on a filter, wash it, and when dry, weigh it; the loss indicates the quantity of oxid of zinc contained in the solution. The oxid of uranium when dissolved in diluted sulphuric acid affords, on evaporation, crystals of a lemon yellow colour.

The undissolved residue of process I. is a mixture of silex, sulphur, and iron which was contained in the ore: the sulphur may be separated as stated, page 40 and 41.

The other ores of uranium may be analysed in a similar manner.

ANALYSIS OF ORES OF MOLYBDENA.

The ores of molybdena at present known, are sulphuret of molybdena, and molybdate of lead.

Sulphuret of Molybdena may be analysed in the following manner:

Process I.—Take one part of the ore freed from all its matrix, put it into a retort containing 3 parts of nitric acid, adapt a receiver, and distil till no more drops fall from the neck of the retort, affuse a new portion of acid on the residue, distil it off again, and repeat this operation until the whole of the ore be converted into a white powder.

II.—Wash this powder well in water, and dry it, it is the oxid, or acid of molybdena.

III.—Mingle the water used for washing the acid, with a solution of potash, till no farther precipitate ensues; this precipitate add to the former, it is also a portion of acid of molybdena.

V.—Having done this, add muriate of barytes to the solution in order to ascertain the quantity of sulphuric acid, according to the rules described, page 52, or proceed thus:

Process I.—Let one part of the ore be repeatedly boiled in sulphuric acid, till the acid refuse to dissolve any more, this solution which should have no excess of acid contains the oxid, or acid of molybdena.

II.—The insoluble residue which consists mostly of sulphate of lead, must be boiled for some time with carbonate of soda, and then washed.

III.—Upon the washed precipitate pour nitric acid, in order to effect a solution. The insoluble powder (if any) is silex.

IV.—Decompose the nitric solution by the addition of sulphuric acid, the precipitate obtained, is sulphate of lead.

V.—Saturate this solution with liquid ammonia, if a precipitate ensues it is iron that was contained in the ore, collect and dry it.

VI.—Having thus far proceeded, evaporate the sulphuric acid solution obtained in process I. to dryness, heat the mass strongly, and digest it repeatedly in diluted nitric acid.

Molybdate of lead may be analysed thus :—Let the ore be dissolved by repeated digestion in muriatic acid, muriate of lead will be deposited, and the molybdic acid remain suspended in the solution, from which it may be removed, as before stated.

ANALYSIS OF ORES OF CHROME.

Chrome exists likewise only in the state of an oxid, combined with lead, or iron. The ores of this metal are chromate of lead, and chromate of iron.

Chromate of Lead.

Process I.—Let one part of the ore mingled with eight of potash, be fused for at least one hour; pour the mass into a convenient vessel, and when cold boil it in a sufficient quantity of water, for ½ an hour, and filter the fluid.

II.—Digest the insoluble part in muriatic acid, decant the solution, wash the residue, and treat it alternately with potash and muriatic acid, until the whole is dissolved.

III.—Mingle the alcaline solutions containing the chrome, saturate it by the admixture of nitric acid, and decompose it, by adding to it nitrate of lead. The precipitate which falls down is chromate of lead, 100 parts when dry indicates 35 of oxid, or acid of chrome.

IV.—The nitric solutions which contain the iron of the ore, together with perhaps a little chromic oxid, may now be mingled together. To separate the latter, drop into it a solution of carbonate of potash, collect the precipitate, and boil it in a solution of potash. What remains is iron.

Chromate of lead may likewise be analysed by treating it successively with muriatic acid; in that case muriate of lead falls down, and the solution contains chromic acid, mixed with a little muriatic acid. The muriatic acid may be got rid of by the addition of nitrate of silver. The chromic acid may be determined, as stated before.

ANALYSIS OF ORES OF TITANIUM.

Titanite exists in the state of an oxid only. The ores of that kind are oxid of titanium and iron, or menachanite; red oxid of titanium, combined with lime and silex; and red shorl, or red oxid of titanium.

Analysis of Menachanite.

Process I.—Let one part of the ore, finely powdered, be fused with 5 or 6 times its weight of potash, or its carbonate; and dissolve the fused mass in water.

II.—Saturate the alcaline solution with muriatic acid, till no further cloudiness ensues, separate the precipitate, which is the oxid of titanium.

III.—Evaporate the solution to dryness, and re-dissolve the residuum in water, the silex will be left behind; again precipitate the solution by potash, and add the precipitate to the oxid obtained before.

IV.—Dissolve the oxid of titanium in sulphuric acid, on adding to this solution phosphoric acid, the titanium will be precipitated, and the iron left behind. For a further account the reader is referred to Klaproth's Analytical Essays, page 496.

ANALYSIS OF ORES OF MANGANESE.

Ores of manganese are very common, but the metallic manganese exists in all of them in the state of an oxid. They differ merely from each other in the degree of oxidation, and other foreign substances which accompany them. Hence they are distinguished from each other, by the appellation of black oxid of manganese, grey or brown oxid of manganese, &c.

Black Oxid of Manganese.—This as well as all the rest of the ores of manganese always contains a portion of iron, but frequently also besides this a variety of different earths, particularly lime, silex, and sometimes barytes.

Process I.—Digest a determined quantity of the ore repeatedly in diluted nitric acid assisted by heat, until this acid acts no farther on the residue.

II.—Upon the ore thus freed from the different earths it may contain, affuse 6 parts of concentrated muriatic acid, and assist its action by a gentle heat. Repeat this operation with half the quantity of acid, until it dissolves no more manganese, which may be known by holding a piece of paper tinged blue with tincture of litmus over the fumes which arise from the vessel. If the blue colour of the litmus paper becomes reddened, the operation is at an end, but if the blue colour be discharged the operation must be continued. The solution may then be decanted, the insoluble residue washed in water, and this water added to the muriatic solution. The insoluble part consists of silex.

III.—Into this muriatic solution, let fall a solution of carbonate of soda, till no farther precipitate ensues, the precipitate is the oxid of manganese and iron, if any was contained in the ore. In order to know if it be pure manganese, boil it in a concentrated solution of potash, the manganese will be dissolved, and the oxid of iron remain behind : by deducting this from the weight of the precipitate, the quantity of manganese may be found.

IV.—To ascertain if the ore contained lime, add to the nitric solution obtained in process I. carbonate of potash, the precipitate produced, after having been ignited, has the properties of lime, if this earth was present.

V.—If the ore contained barytes, the nitric solution may be assayed by sulphuric acid, which in that case occasions a white precipitate. All the other ores of manganese may be analysed in a like manner.

ANALYSIS OF THE ORE OF COLUMBIUM.

To the genera of ores so far considered Mr. Hatchett has added a new one, to which he has given the name of columbium.

This ore is of a dark brownish grey externally, and more inclining to an iron grey, internally. Its longitudinal fracture is lamellated, its cross fracture has a fine grain. Its lustre is vitreous, slightly metallic. It is moderately hard, and very brittle. Its colour is a chocolate brown, and is slightly magnetical. In this ore columbium exists in the state of an acid, combined with iron. Mr. Hatchett discovered this ore in the year 1802, on examining and arranging the minerals of the British Museum. His analysis is as follows:

Process I.—One part of pulverised ore was mixt with 5 times its weight of carbonate of potash, and fused in a silver crucible.

II.—The alcaline mass was dissolved in boiling water, the insoluble part separated by the filter, and repeatedly washed in water.

III.—The filtered fluid was mingled with muriatic acid in excess, the result was a white flocculent precipitate, being the columbic acid contained in the ore.

IV.—The insoluble residue of process II. was digested in muriatic acid, in order to get rid of the iron; the acid being decanted, the residuum after being washed, was again fused with carbonate of potash, dissolved and precipitated with nitric acid alternately, till the whole was decomposed.

V.—The muriatic solution was now decomposed by liquid ammo nia, a copious ochreaceous precipitate fell down, which was redissolved in nitric acid, and the solution decomposed by means of ammonia. The iron was thus obtained.

VI.—The different alcaline solutions were mixed together, and being supersaturated with nitric acid, yielded the same white precipitate, (columbic acid.) The fluid from which the precipitate had been separated by nitric acid, was then saturated with ammonia, and being boiled afforded a small quantity of oxid of iron: 200 parts of the ore, thus analysed, yielded Mr. Hatchett 42 of oxid of iron, and 155 of columbic acid. For a fuller account of Mr. Hatchett's analysis we refer the reader to his paper in the Philosophical Transactions, 1802, part I. p. 40.

ANALYSIS OF ORES OF TANTALIUM.

Since the discovery of the last mentioned ore, a new metallic substance has been announced by Mr. Eckeberg, which is said to exist in the mineral called gadolinite, and also in a peculiar species of tin ore, called by the Germans, zin-graupen. In the first mineral, the metal is said to exist combined with oxid of iron and manganese, and in the latter united to yttria. The discoverer has called this metallic substance tantalium. The metal is distinguihed from all others by being insoluble in any of the acids. Whether this substance will retain its place among the metals, must be left to future investigation; at present we have only the authority of Mr. Eckeberg for inserting it.—*See Journal de Minis, No. 20, An.* X. p. 248, *and the Author's System of Practical Chemistry*, vol. II. p. 184.

EXAMPLE ON AN ANALYSIS OF AN ALLOY COMPOSED OF DIFFERENT METALS.

From what has been stated in the preceding pages, it will be obvious that the separation of different metals, from other substances with which nature had combined them in the bosom of the earth, is totally owing to the different affinities, which different metallic substances possess to certain bodies. This being once known, the analysis of a metallic compound consisting of a variety of different metals, will become easy. Suppose therefore that a metallic mass was made up of platina, gold, bismuth, silver, lead, iron, and copper. The separation of these metals might be effected in the following manner:

Process I.—Let the alloy be comminuted either by filing, or granulation, and digest it in diluted nitric acid, till this agent exercises no farther action on the residue. Mingle the different solutions, and put the insoluble residue, which consists of the gold and platina, a side for further examination.

II.—Mingle the obtained nitric solution with water, till a new addition of this fluid occasions no farther turbidness. Suffer the precipitate which is thus formed to subside, collect it by the filter, and dry it. This is the oxid of bismuth: 123 parts, when dry, are equal to 100 of metallic bismuth; or it may be reduced to its metallic state, by fusing it briskly in a crucible under a cover of charcoal dust.

III.—Concentrate the fluid from which the bismuth has been separated, and immerse into it a cylinder of copper, the silver will become precipitated in a metallic state.

IV.—To separate the lead drop into the fluid of the last process sulphuric acid, till no farther precipitate falls down. This precipitate is sulphate of lead; 100 parts of it when perfectly dry, contain 30 of metallic lead.

V.—The fluid from which the lead has been separated, must now be mixt with liquid ammonia; a brown precipitate falls down, which is the iron that was contained in the alloy. Let it be ignited for at least one hour, and weigh it.

VI.—The solution from which the iron has been separated may be decomposed by mixing it with a solution of potash, and boiling it a little; the ammonia becomes volatilized, and an oxid of copper is precipitated. To obtain the copper in a metallic state, dissolve this oxid in sulphuric, or muriatic acid, and immerse into it a cylinder of iron. The copper will then become separated in a metallic state.

VII.—Having thus far proceeded, take the insoluble residue left in process I. dissolve it, by digesting it repeatedly in nitro-muriatic acid, till a compleat solution is effected. Mingle this fluid with a solution of muriate of ammonia, the platina will be separated, and the gold left in the solution; to reduce the platina to its metallic state, expose the precipitate to the most intense heat that can be raised.

VIII.—To recover the gold, mingle the solution from which the platina has been separated with a diluted solution of green sulphate of iron, a precipitate falls down, which is metallic gold; collect and fuse it into a mass.

The analysis is now compleated, if the sum total of the obtained products correspond with the weight of the substance submitted to examination, we are certain, that we have operated accurately, if not, the analysis must be repeated, in order to discover the error.

GENERAL VIEW OF THE AVERAGE SPECIFIC GRAVITIES OF DIFFERENT METALLIC ORES.

THE average specific gravities of ores of different metallic substances, when freed as much as possible from heterogeneous matters, are as follow: The specific gravity of

Crude Platina reaches from	20.6 to 22
Gold ores	5.7 to 11.8
Silver ores	5.8 to 10.6
Copper ores	5.2 to 6.5
Lead ores	5.1 to 7.18
Tin ores	5.3 to 6.97
Iron ores	5.6 to 8.5
Zinc ores	5.0 to 5.5
Mercury ores	5.4 to 7.75
Antimony ores	5.1 to 6.
Bismuth ores	5.8 to 8.6
Nickel ores	5.5 to 6.5
Cobalt ores	5.3 to 7.2
Arsenic ores	5.1 to 6.8
Tungsten ores	5.8 to 7.5
Tellurium ores	5.4 to 6.
Uranium ores	5,2 to 5,5

Molybdena ores	5.2 to 6.2
Chrome ores	5.3 to 6.5
Titanium ores	5.1 to 6.
Manganese ores	5.1 to 6.8
Columbium ore	5.918
Tantalium ores, not yet ascertained.	

For a summary view of external characteristic properties of ores, the reader is referred to Kirwan's and Babington's Mineralogy, vol. II. p. 335.

CLASS II.

EARTHS AND STONES.

THOUGH there seems to be an almost infinite variety of earths and stones scattered on the surface of the globe, yet when this subject is examined with a chemical eye, we find, not without surprize, that all the stones we tread under our feet, as well as the vast variety of specimens we meet with in the cabinets of the curious, and even the mould in which vegetables grow, are all composed of a very few earths, in number no more than ten: moreover, of these simple earths seldom more than four or five are found combined together in one substance, met with in nature.

NATURAL HISTORY OF EARTHS AND STONES.

The slightest acquaintance with the stony substances, that come under our inspection, is sufficient to convince us that they were once in a soft or liquid state. A vast number of earths and stones have a regular symmetrical arrangement, they appear to have been crystallized like salts, and must therefore have been separated from their solvent, whatever that may have been. The variety of crystals of stones and earths discover all the figures and modifications of primitive forms, observable in other substances, when suffered to crystallize under favourable circumstances. Moreover, many stones inclose organized substances, which they could not have admitted, but in a soft or fluid state; others are evidently formed round different substances, as these, having received their shape and form, the operations of art could never have introduced themselves into them. The bare mention of these circumstances is sufficient, as this point cannot possibly be disputed. The only difficulty that offers itself is, to ascertain the nature of that fluid which was capable of holding in solution, or perhaps in suspension, that immense mass of solid substances of which the stony part of the globe consists. Concerning this subject different theories have been advanced. Kirwan remarks, that with regard to stony matters placed deeper than one mile beneath the level of the sea, we have no reason to affirm that they were ever in a soft state, as we are absolutely unacquainted with them; with respect to those that are nearer to, or on the surface of the earth, we may for the present suppose that fluid to have been in most cases mere water, in some circumstances assisted by saline substances, and in comparatively much fewer cases, aided by volcanic fires. In vain however have philosophers endeavoured to form perfect theories of this subject. If it were permitted to man to follow, during several ages, the various changes which are produced on the surface of our globe, by the numerous agents that alter it, we might perhaps be in possession at this moment of the most valuable information respecting this subject; but thrown as we are upon a small point of this vast theatre of observation, we can only fix our attention for a minute to reason upon subjects which have employed the works of nature for ages, and disappear ourselves at the moment wherein we have proceeded so far as to collect a few facts.

It must nevertheless be acknowledged that those men who by the mere efforts of their imagination, have endeavoured to form ideas respecting the construction and the great phenomena of this subject, have numerous claims to our indulgence. Amongst these we have to mention particularly Kirwan and Hutton. In their proceedings we behold the efforts of genius tormented with the desire of acquiring knowledge, and irritated at the prospect of the scanty means which nature has put in its power. They have endeavoured to embellish their hypotheses with every ornament which immagination and eloquence can furnish, either as instruments of illusion or entertainment: we ought to consider ourselves highly indebted to them.

CHARACTERISTIC PROPERTIES OF EARTHS.

Earths when in a state of purity, are concrete, friable, white, and opake substances, whose specific gravity never exceeds five times that of water. They exhibit no metallic lustre. They are infusible, and absolutely incombustible, or inconsumable in fire. They are insoluble in water, in the common acceptation of the word. Most of them have no perceptible taste. They are capable of combining with acids, and forming with them a peculiar class of bodies, called salts. They are likewise disposed to unite with alcalies, with sulphur, with phosphorus, and with each other.

In some systems of mineralogy a distinction is made between earths and stones, but this is of no utility. Stones differ from earths, merely in cohesion and hardness; and hence they are more properly included in one class. For a stone in fact is nothing more than a hard earthy mass, and an earth in powder is an aggregate of very minute stones. For instance sand or grit-stone, are particles of sand united by the force of aggregation into one mass called a stone; and sand is an accumulation of grit-stone, whose integrant *moleculæ* are disunited: both substances have precisely the same chemical properties.

All the earthy and stony substances are classed and named according to the nature of that particular substance, which forms its most predominant part.

DIVISION OF EARTHS AND STONES.

From what has been premised mineralogists have divided earths and stones into the following different genera. Each genus derives its name from the particular earth which constitutes its most predominant part, namely;

Silicious genus
Calcareous
Aluminous
Magnesian
Barytic
Strontian genus
Glucine
Zircon
Yttria
Augustine

In examining these different genera of stones, we shall previous to their analysis trace out some obvious physical marks, and chemical properties, by which we may be enabled to ascertain the nature of the stones which are unknown to us, so far at least as to enable us to bring them under one of the above genera, and to facilitate the chemical examination of stones in general, to be considered hereafter.

ANALYSIS OF SILICIOUS STONES.

Most of the stones belonging to this genus are transparent; they have a vitreous appearance, and a high polish. They are very hard, and scratch glsss. They are not acted upon by any acid, the fluoric excepted. They fuse with alcalies, and form with them, in certain proportions, a substance called glass. They likewise melt with the glacial acid of phosphorus, and with boracic acid. They do not adhere to the tongue, nor do they discover any peculiar odour when breathed on. Stones composed chiefly of pure silicious earth are transparent and colourless. Their specific gravity is seldom more than 2.88.

When a stone possesses most of the properties which characterise the silicious genus, we may proceed to the chemical examination of it, in order to ascertain with more certainty whether it really belongs to this genus, or not, in the following manner:

Process I.—Let a determinate portion of the stone be heated to redness, plunge it suddenly into cold water, and repeat this operation for several times successively, until the stone is become considerably friable.

II.—Let one part of the stone thus prepared be reduced to a fine powder, mix it with 4 or 5 parts of potash, dissolved in a like quantity of water; put the mixture into a silver crucible, and evaporate it to dryness, keeping the mixture constantly stirred with a silver rod, to prevent the potash from swelling and throwing part of the mass out of the crucible, when the whole is evaporated to dryness, let the fire be gradually augmented, until the crucible is of a dull red heat, or till the mass fuses quietly. Keep it in that state for at least one hour. From the appearance of the mass in the crucible we may form some conjecture respecting the predominant earth contained in the stone ; for if the mass flows thin like water, we may be certain that the stone consists chiefly of silicious earth, and therefore belongs to the silicious genus.

III.—Let the crucible before it is completely cold, be removed out of the fire, soften the contents of it by water, and renew the affusion of that fluid from time to time, till all the fused mass is detached from the crucible, then add at least 12 times its bulk of water, in order to effect a solution. If the stone belonged to the silicious genus, the fused alcaline mass will now be totally soluble in water, or at least nearly so.

IV.—Into the before obtained alcaline solution, pour muriatic acid until no farther precipitate ensues, and evaporate the whole to dryness without separating the precipitate.

V.—Upon the dry mass affuse six times its bulk of muriatic acid, previously diluted with four parts of water, boil the mixture for half an hour, suffer the insoluble part to subside, collect it on a filter, dry it, and expose it to a red heat in a crucible: this powder is the quantity of flint, or silex, that was contained in the stone. Its weight, after being ignited, ought to amount to at least somewhat more than one half of the original weight of the stone submitted to examination.

Stones belonging to the silicious genus are, rock-crystal, quartz, flint, chert, calcedonies, jaspers, agates, carnelions, porphyry, topazes, opals, elastic quartz, or flexible marble; granits, pitch-stone, grit-stone, chrysophrass, adularia, &c. They may be analysed in a similar manner, at least with a view to determine their proportion of silicious earths.

ANALYSIS OF CALCAREOUS STONES.

To this class of earth belong all those stony mixtures in which the properties of lime predominate. Pure calcareous earth, or lime, is very rarely met with in nature. This earth is more generally combined with different acids, particularly with the carbonic and sulphuric acids. It exists however also in combination with phosphoric, fluoric, and boracic acids. Calcareous stones are never hard enough to strike fire with steel. Their specific gravity is always less than 3 times that of water. They can be scratched with a pen-knife. All of them are easily reduced to powder, and some are quite friable between the fingers.

As it is impossible to point out a ready method which could be applicable to the examination of all stones of this genus, we shall consider them under certain sections, namely:

1st.—*Calcareous stones which are readily soluble in nitric or muriatic acid, with more or less effervescence.*

2dly.—*Calcareous stones which are not soluble in nitric or muriatic acid; or at least far more difficult, and which do not effervesce.*

To the first species belong all the stones properly called carbonates of lime, or lime-stones. They may be distinguished and analysed in the following manner:

Carbonate of Lime.

The stones belonging to this division are soluble in nitric or muriatic acid, with efferverscence, or nearly so. They yield carbonic acid gas when exposed to heat, and become converted into quick-lime. They do not form an uniform mass, when fuesd with potash or soda.

As, however, most of these properties are also peculiar to barytic stones, they may at once be distinguished from the latter, by their specific gravity; for the stones of the barytic genus exceed considerably in specific gravity those of the calcareous. The specific gravity of the barytic genus is always above 4, whilst that of the calcareous, is always less than 3. For the sake of certainty, however, they may be chemically examined thus:

Process I.—Take a determinate quantity of the stone, reduced to an impalpable powder, digest it repeatedly in muriatic acid, until this fluid exercises no further action upon it; dilute the solution, filter it, and collect the insoluble residue on the filter; dry it, and ascertain its weight.

II.—Dilute the solution with 24 times its bulk of water, and drop into it diluted sulphuric acid; if the stone contains barytes a precipitate ensues. Let it be collected, dried, and weighed.

III.—Having done this, add to the filtered solution, from which the barytes has been separated, (if any was contained in the stone,) a solution of carbonate of soda, till no more precipitate ensues: collect the precipitate, and dry it, at least so much so, that it may be transferred from the filter conveniently.

IV.—Pour over the precipitate obtained in the last process, sulphuric acid, till no farther effervescence ensues.

V.—Let the whole be introduced into a mixture of 3 parts of distiled water and one of alcohol, in the proportion of 8 parts of the mixture to the quantity of the substance which was before dissolved in nitric acid; digest the whole in the cold for some hours, filter off the fluid, dry the insoluble part, and weigh it.

VI.—Let the fluid obtained in the last process be decomposed by the addition of a solution of carbonate of potash, collect the precipitate, wash, and dry it.

If the substance, thus examined, properly belongs to the genus of carbonate of lime, the weight of the insoluble part obtained in process V. after deducting from it $\frac{1}{3}$ part, must exceed the weight of the insoluble parts of process I. and II.

Carbonates of lime may also be distinguished from other stones, by becoming converted into quick-lime, after having been exposed to a red heat for some hours, during which process stones of this genus lose about 40 parts. The remaining earth is quick-lime.

Stones belonging to this species, or carbonates of lime, are all the varieties of what are commonly called *lime-stones, chalks, marbles, stalactites, pearl-spars, marls, testaceous tufas, swine-stone, &c.*

Calcareous stones, which are not soluble in nitric or muriatic acids, or sulphate of lime, may be analysed in the following manner:

Process I.—Let one part of the mineral, finely powdered, be boiled with 4 times its weight of carbonate of potash, in a sufficient quantity of water, for at least 2 or 3 hours, renewing the fluid as it evaporates, and collect the insoluble mass.

II.—Transfer the insoluble part into a flask, containing diluted nitric acid; effect a solution, if possible; evaporate it to dryness, and weigh the mass.

III.—Pour upon the dried mass, more than its own weight of strong sulphuric acid, apply heat gradually increased till no more fumes rise: weigh it again.

IV.—Digest the insoluble part in twice its weight of cold water, filter off the fluid, and dry the insoluble residue in a dull red heat. To estimate the quantity of lime, deduct from the weight of the insoluble mass left in process III. 59 parts: the remainder gives the quantity of lime; or,

V.—If the insoluble mass of process II. be exposed to a red heat for some hours, it will be converted into quick-lime.

In a similar manner may be examined all the different varieties of sulphates of lime, known by the names of *compact*, *fibrous plumose*, *foliated*, *specular*, *gypsum*, &c.

The combination of lime with fluoric acid, or fluates of lime, may be examined in the following manner.

Fluates of Lime.—The stones belonging to this species are composed of lime united to fluoric acid, they are both amorphous and crystallised. They decrepitate and become phosphorescent when exposed to heat, except the colourless ones, which become electric by friction. They are generally crystallised in cubes. They are more or less transparent, and exhibit various colours, particularly violet, purple, red, yellow, and white. They melt before the blow-pipe into a transparent glass. They take a fine polish and are worked into beautiful vases, vessels, and a variety of ornaments, by Messrs. Brown and Maw, Tavistock Street. The stones belonging to this genus are all decomposeable by sulphuric acid, the fluoric acid becomes expelled, and may be known by the property of dissolving glass; for that purpose let a quantity of the powder be moistened with sulphuric acid in a leaden or pewter vessel; heat the mixture over a lamp, and expose to the acid vapours, a plate of glass, which will soon become corroded. Their phosphorescent property may be evinced, by throwing the stone, reduced to a coarse powder, upon a shovel, or plate of metal, heated so as not to be visible in the day.

Phosphate of Lime, or lime combined with phosphoric acid, forms the mineral called appatite, phosphorite, or chrysolite.

This combination of lime sometimes appears amorphous and sometimes crystallised. Its colour is commonly gray, or green, sometimes brown, red, blue, and even purple. It is infusible by the blow-pipe. It is soluble in muriatic acid, with scarcely any effervesence, and the solution afterwards becomes gelatinous: when scratched with a knife, in the dark, it becomes phosphorescent; and when laid upon red hot coals, it emits a yellowish green phosphorescent light. It may be examined thus:

Process I.—Digest a determined quantity of the mineral in 5 times its quantity of muriatic acid, and repeat this operation till the fluid acts no more upon the residue, decant the fluid, dilute it with water, and filter it.

II.—Mingle the muriatic solution with liquid ammonia, collect the precipitate, wash, dry, and heat it.

III.—Re-dissolve this precipitate in a sufficient quantiy of nitric acid, and precipitate by the addition of sulphuric acid. The whole must then be filtered, and the insoluble part washed with as little water as possible.

IV.—The filtered fluid must now be evaporated to the consistence of a syrup. If the stone consists of phosphate of lime, the fluid thus obtained will be phosphoric acid. That it is phosphoric acid may be proved by its copious precipitation of lime water, by is giving white precipitates with the solutions of sulphate of iron and nitrate of mercury, and its incapability of precipitating the nitrate, and muriate of barytes.

Borate of Lime, or the combination of boracic acid, with calcareous earth, constitutes the mineral, called boracite.

This mineral is crystallised in cubes with truncated edges and angles ; before the blowpipe it froths, emits a greenish light, and becomes converted into a yellowish enamel. When heated it beomes electric. It is more or less semi-transparent ; it has mostly a vitreous appearance. It does not crackle when suddenly exposed to heat. Its specific gravity is about 2,560. It may be examined in the following manner.

Process I.— Digest one part of the mineral repeatedly in nitric acid by heat, till a new addition of acid does not produce any further action on the residue.

II.—Decompose the nitric solution by carbonate of soda, and separate the precipitate by filtration.

III. —Mingle the solution with sulphuric acid, till the taste of the latter predominates : evaporate the fluid to dryness.

IV.—Transfer the dry mass into alcohol, degest it by heat, and then evaporate the alcoholic solution If now a salt is left behind, which reddens tincture of litmus, and which tinges the flame of burning alcohol green, the subtance examined was borate of lime, or boracite.

ANALYSIS OF ALUMINOUS EARTH.

Earths and stones belonging to this genus may be discriminated by the following general properties: They are almost entirely destitute of transparency; they exhibit no crystaline or regular shape; they have mostly a dry and opake appearance, and are destitute of vitreous lustre; they are soft to the touch, and all emit a peculiar odour when breathed upon, known by the name of a clayey smell. They are all more or less acted upon by acids, but they do not effervesce. They are not hard, but their surface may be scratched with a knife; many of them suffer impressions by the finger-nails, but they become very hard after having been exposed to a violent heat. The softer kinds absorb water rapidly, and form, when mixed with that fluid, a kneadable, tenacious, and ductile mass.

If a substance is found whose appearances and properties coincide, or nearly so with the description here given, we have to ascertain whether it may properly belong to this genus, respecting its predominating component parts.

For that purpose we must proceed in the following manner.

Process I.—Let one part of the earth, or stone, be boiled in sulphuric acid to dryness, on the dry mass, pour a fresh portion of acid, boil again to dryness, and repeat this process for several times.

II.—Affuse upon the mass water acidulated with sulphuric acid, digest it for ½ an hour, transfer the mixture upon a filter and wash the insoluble residue, by pouring boiling water over it repeatedly.

III.—Into this fluid let fall a solution of carbonate of potash, collect the precipitate, wash, and dry it.

IV.—Transfer the precipitate into acetous acid, and digest it in that fluid for one hour; after this let the whole be put upon a filter, wash it with a little water, dry it, and ignite it for ½ an hour. If the weight of this earth now exceeds one half of the quantity of the substance which was examined, it then belongs to the aluminous genus.

ANALYSIS OF EARTHS AND STONES OF THE MAGNESIAN GENUS.

Most of the stones of this genus have almost all a greenish colour: they have, more or less a glittering or shining surface, seldom, if at all, an earthy appearance, but they do not adhere to the tongue; they hardly ever exhibit a regular crystaline form; they do not, or very seldom, affervesce with acids, but they are soluble in boiling sulphuric acid. Their texture is generally scaley or lamellar: seldom they have an even texture. They are only semi-transparent, but in general inclined to opake. Their substances are almost more or less smooth, and soft, or rather soapy to the touch: they do not stain the fingers, nor do they soften in water like the argillaceous genus. They discover no clayey smell by breathing upon: they may be cut with a knife, or with a machine: they do not contract or harden after having been exposed to heat, and are infusible with potash.

Process I.—Let one part of the stone be ground to a fine powder, pour over it two or three parts of sulphuric acid, diluted with half a part of water, boil the mixture to dryness, and heat it till no more white fumes rise.

II.—Transfer the dry mass into twice its weight of water, digest it in the cold for some hours, and then filter it. It yields on evaporation, a crystaline salt of a bitter taste. Dissolve it in water.

III.—Decompose this solution by carbonate of potash, dry the precipitate, and heat it; which, if the stone belonged to the magnesian genus, will be the earth called magnesia, which may be distinguished from alumine by being insoluble in caustic potash, and forming bitter salts with sulphuric acid.

Stones containing magnesia in considerable quantity are: Serpentines, Steatites or Soap-rocks, Chlorite, Talcs, Asbestus.

ANALYSIS OF STONES OF THE BARYTIC GENUS.

The stones belonging to the barytic genus, are particularly distinguished by their superior specific gravity, in which they exceed all other stones and earthy minerals. Their specific gravity is four, or at least near to it: exposed to heat they emit a phosphorescent light. They have a spongy appearance: they are less hard than silicious stones, and may therefore be scratched with a knife. All substances belonging to this genus may be divided into two general species: the one are totally soluble in diluted nitric and muriate acids (carbonate of barytes): the other species belonging to the genus which have a spongy appearance, are not acted upon by any acid (sulphate of barytes).

Carbonate of Barytes.

Process I.—Dissolve a determinate quantity of the mineral, in diluted nitric acid, and assay a portion of this solution by sulphate of soda; if a precipitate ensues on adding a small quantity of the salt to the solution of the earth diluted with 24 times its bulk of water, we may conclude it belongs to the barytic genus; but in order to be certain, proceed as follows:

II.—Evaporate the nitric solution to dryness, and expose it to a white heat in a silver crucible; the earth thus obtained is barytes; it is soluble in 20 times its weight of water; and if the solution be evaporated, yields crystals of long, four-sided priems. It separates sulphuric acid from all its combinations. If we drop a crystal of this earth into a solution of sulphate of soda, a white precipitate will instantly ensue.

The Analysis of Sulphate of Barytes is analogous to the examination of sulphate of strontia, which shall be noticed in the next page.

ANALYSIS OF STONES OF THE STRONTIAN GENUS.

Of this genus of earth there are likewise only two species known at present. In the one, the strontian earth is combined with carbonic acid; and in the other it is united to sulphuric acid. The first species appears in solid masses; it is composed of long fibres, adhering to each other, and disposed in a radiated manner. Its colour is generally whitish, and asparagus green, which appears deeper towards the centre of the mass. When broken, its surface is a little shining in certain directions; it is brittle, and has a little transparency. Its surface can be scratched with a knife: its specific gravity is from 3. 4 to 3. 66. The solution of this earth in nitric or muriatic acid, when evaporated to dryness, tinges the flame of alcohol, carmine red.

Sulphate of strontia occurs both amorphous and crystalised, most commonly in bevelled tables, sometimes in rhomboidal cubes, set edgways in the matrix. Its texture is foliated, and more or less transparent. The specific gravity of this mineral reaches from 3.51 to 3.96. Its colour is most commonly reddish, or sky blue, and sometimes colourless.

Carbonate of Strontia.

Process I.—Dissolve a determinate quantity of the stone supposed to be corbonate of strontian in diluted nitric acid, evaporate the solution, and suffer it to crystalise; collect a portion of these crystals, and, when dry, moisten them with alcohol in a silver spoon. Set fire to the mixture, and hold it while burning over the flame of a candle, and cause a quick and rapid combustion. The flame of the alcohol will be tinged beautifully red.

II.—Expose the nitrate of strontia to a red heat, and obtain the earth from this nitrate in a similar manner as directed for obtaining barytes. The earth thus obtained should amount to more than one half of the stone employed. It has the property of tinging the flame of alcohol carmine red: in this respect it differs from barytes.

Sulphate of Strontia.

Process I.—Boil one part of sulphate of strontia, reduced to an impalpable powder, with 3 or 4 of carbonate of potash in 12 of water for about two hours, renewing the water as it evaporates, and agitate the mixture frequently.

II.—Decant the supernatant fluid, and wash the insoluble residue in water.

III.—Transfer this insoluble powder into diluted nitric acid, and effect a solution.

IV.—Evaporate the fluid to dryness, and expose it to a white heat: the earth thus obtained is strontian.

ANALYSIS OF STONES OF THE GLUCINE GENUS.

This earth has hitherto been found only in 3 stones, namely; in the Aigue-marine, or Beryl, a transparent stone of a green colour; in the Emerald of Puru, a stone of a similar colour; and in the Gadolinite.

To obtain the glucine earth f om theses stones, proceed as follow:

Process I.—Fuse one part of the stone with 4 of potash as usual, dissolve the alcaline mass in water, and filter it.

II.—Drop into the alcaline solution, muriatic acid till no further precipitate ensues, separate the precipitate (which is silex) from the fluid by filtration.

III.—Decompose this fluid by adding to it a solution of carbonate of potash, and wash the precipitate.

IV.—Re-dissolve the precipitate in sulphuric acid, mingle this solution with a small portion of sulphate of potash, and evaporate the fluid; the salt which crystallises is sulphate of alumine; separate these crystals, and mix the fluid with a solution of carbonate of ammonia in excess, filter and boil it, a white powder gradually falls down, which is glucine earth.

ANALYSIS OF STONES OF THE ZIRCON GENUS.

Hitherto this earth has been found only in two precious stones; namely, the Zircon, o

Jargon of Ceylon, and the Hyacinth. The uncut zircon exists of various colours, but in general the stones from Ceylon are of a reddish brown, inclining to a dim smoaky gray. They have a greasy gloss, and feel unctuous, or smooth to the touch. The size of the individual stones is very inconsiderable. They resemble small flat pebbles: commonly 20 or 30 of them weigh only one dram. This gem is eminently distinguished by its specific gravity, which is from 4.530 to 4.615. The hyacinth which is also imported from Ceylon is a well-known gem. Its specific gravity in general, nearly agrees with that of the jargon, that is according to its varieties from 4.545 to 4.625: the zircon, or jargon is composed of zircon earth, silex, and oxid of iron. The zircon may be examined in the following manner:

Process I.—Digest the finely pulverised mineral, repeatedly in nitro-muriatic acid, and wash the residue.

II.—Mingle the solution with liquid ammonia, the precipitate which ensues is oxid of iron.

III.—The zircon thus purified from this metal, must be melted with potash: after the mass has fused for a few hours, let water be poured gradually into the crucible to soften the mass; in order to effect a solution add more water, and transfer the whole on a filter.

IV.—Let the filtered solution be saturated with sulphuric acid; on evaporating the fluid, a white precipitate falls down which is silex.

V.—The insoluble residue which is left on the filter, must now be diffused through a sufficient quantity of water, and so much sulphuric acid added as is necessary to effect a solution by means of heat.

VI.—Let the fluid be evaporated until it has acquired a considerable degree of concentration: it then becomes gelatinous.

VII.—When this gelatinous mass is again digested with a larger quantity of water, it separates into the form of transparent viscid grains: these, when collected on a filter, and exsiccated, will be found to resemble glassy sand.

VIII.—The dry mass must again be fused with potash, dissolved in water, and the insoluble part separated by the filter.

IX.—Mingle the solution of the last process with sulphuric acid, the precipitate which falls down is silex.

X.—The insoluble residue left in process IX. must then be dissolved in sulphuric acid, and mixed with the solution before obtained. On adding to this fluid carbonate of potash, a precipitate falls down, which, after having been ignited, is zircon earth in its pure state.

The hyacinth may be examined in a similar manner.

ANALYSIS OF THE STONE CONTAINING YTTRIA.

The earth called yttria is found only in a fossil called ytterby or gadolinite. The colour of this mineral is black, and its fracture exactly like that of glass. It is magnetic, and soft enough to be scratched with a knife, and often even by the nail. Its specific gravity is 4.0497. In this mineral yttria exists, combined with oxids of iron and manganese, a little lime, and a considerable quantity of silex.

The analysis of this mineral may be conducted in the following manner:

Process I.—Let the fossil be repeatedly digested in muriatic acid. The insoluble residue consists of silex.

II.—Decompose this muriatic solution by

liquid ammonia, collect the precipitate, boil it in a solution of potash, and filter the fluid.

III.—Dissolve the insoluble residue of the last process in diluted sulphuric acid, evaporate the solution to dryness, ignite, and re-dissolve it in water; a precipitate falls down, which must be separated by the filter.

IV.—The filtered solution, when mingled with liquid ammonia, yields a precipitate which is yttria.

ANALYSIS OF THE STONE CONTAINING AUGUSTINE.

This newly-discovered earth is said to exist in the Saxon Beryl, or Beryl of the metalliferous mountains of Georgian Stadt; a mineral greatly resembling the Beryl of Siberia; but as this earth has hitherto been only found by professor Tromsdorf, the existence of it as a peculiar earth must still remain doubtful, till the conclusions of its discoverer be confirmed by other philosophers. The analysis of the Beryl was conducted by Tromsdorf in the following manner:

Process I.—The beryl submitted to examination was boiled with potash, the mixture evaporated, and then fused in a silver crucible.

II.—The mass was softened with water, and dissolved in muriatic acid.

III.—The obtained solution was evaporated to dryness, re-dissolved in water, and filtered; the insoluble part consisted of silex.

IV.—The solution was precipitated with soda, washed, dried, and boiled in a solution of caustic potash.

V.—The insoluble part of the last process consisted of the new earth: 100 grains of the above mineral yielded by this analysis 15.0 silex; 4.5 alumine; and 78.0 augustine.

GENERAL ANALYSIS OF EARTHS AND STONES.

In the preceding pages we have considered earths and stones solely with a view to discover their principal prevalent component parts, in order to determine therefrom the genus to which the mineral belongs; we shall now enlarge upon this subject more fully, by pointing out some general observations, which may serve as a guide for separating all the different earths that may exist in a mineral submitted to our examination. In the analysis of earthy substances, or stones, we must first attend to their solubility or insolubility in acids, and with that view we divide them into two classes, namely, earths and stones, which effervesce with, and are either totally or nearly soluble in nitric acid, diluted with five or six times its weight of water; and such as are not soluble in that acid. Suppose therefore that the stone to be examined consisted of silex, alumine, magnesia, lime, strontia, and barytes.

The method of separating these different earths will become obvious from the following considerations:

Process I.—Reduce a quantity of the mineral to powder, and try whether it effervesces with nitric or muriatic acid, diluted in the above proportions; if so, let a determinate quantity be put into a tubulated retort of as little capacity as possible, immerse the neck of it under a cylinder filled with water, and placed in the pneumatic apparatus.

II.—Let a quantity of muriatic acid be put at once through the tubulure, or opening at the top of the retort, and immediately stop it, so as to be air tight.

III.—When no more gas is liberated by the addition of a fresh portion of acid, assist the action by heat, and transfer the cylinder containing the gas into lime water, the carbonic acid will now be absorbed: the loss of the whole bulk, after deducting the air which was contained in the retort, indicates the quantity of carbonic acid contained in the stone.

IV.—The substance from which the carbonic acid has been expelled, must be diluted with double its weight of water, and filtered; the insoluble part, if any, put aside for further examination. The solution may contain lime, magnesia, alumine, barytes, and strontia.

V.—In order to ascertain if barytes or strontia be present, dilute a small portion of the solution with 24 times its bulk of water, and drop into it a solution of sulphate of soda. If barytes or strontia (or both) be present, a cloudiness will take place, and a white precipitate will gradually be deposited.

VI.—Having thus investigated the presence or absence of these earths, our next object is to separate them. Suppose they should both be contained in the fluid? For that purpose add a solution of sulphate of soda till it produces no further cloudiness; when the precipitate has subsided, collect it on a filter; wash and dry it.

VII.—Boil this precipitate, with four times its weight of carbonate of potash, in a sufficient quantity of water for at least one hour, supplying this fluid as it evaporates, then suffer the insoluble part to subside, and wash it.

VIII.—Transfer the insoluble part of the last process into nitric acid, of the specific gravity 1.4, diluted with an equal weight of water. The carbonate of strontia which it contained will be dissolved, but the barytes will not be acted upon; the weight of the latter, deducted from the weight of the whole, gives the quantity of each, or the two may be separated by adding to the nitric solution, barytic water, till no farther precipitate ensues; the barytes in this case will seize the acid, and the strontia will be thrown down; but in this case it is essential that the nitric solution of the earth is perfectly neutral, or has no excess of acid.

IX.—The strontia and barytes being thus separated, heat the fluid, and drop into it a boiling solution of carbonate of soda: the precipitate which falls down may consist of all the remaining earths which were contained in the solution, namely; lime, magnesia, and alumine. In order to separate them, proceed as follows:

X.—Boil the precipitate in a solution of caustic potash for at least half an hour, dilute the fluid with water, and separate the insoluble part by the filter, the alumine will now be dissolved by the potash, and the other earths remain untouched.

XI.—To separate the alumine, neutralize the alcaline solution by muriatic acid, a precipitate falls down, wash it, and expose it to a red heat. It is the alumine which was contained in the mineral.

XII.—To separate the other earths, dissolve the residue of process X. in nitric or muriatic acid, evaporate the solution to dryness, weigh the dry mass, and pour on it at least double its weight of sulphuric acid, and heat the mixture till no more white fumes rise. Digest the mass in twice its weight of cold water, filter it, and dry the insoluble part in a low red heat.

XIII.—The insoluble portion of the last process contains the lime, combined with sulphuric acid. To ascertain its quantity, deduct from its weight 59 per cent.; the remainder is the quantity of lime.

XIV.—To obtain the magnesia, concentrate the fluid obtained in the 12th process to one third of its original bulk; make it boiling hot, and decompose it by a solution of carbonate of potash, collect the precipitate, expose it to a red heat till it does not effervesce by the addition of an acid. It will then be the pure magnesia contained in the mineral.

Stones insoluble in diluted nitric, and muriatic acids.

Process I.—Take a determinate quantity of the stone reduced to an impalpable powder, mix it with at least three times its weight of potash, and fuse the mass thoroughly in a silver or platina crucible. From the phenomena which takes place during this process, we may already form some conjecture concerning the nature of the stone submitted to examination. If the mass fuses completely, silicious earth predominates; but if the fusion remains imperfect, and the mass cannot be rendered liquid, the other earths are most abundant. If it remains in a powdery form, and can partly be rendered liquid, and if the bulk of the mass has been considerably increased, then alumine may be expected to be the most prevalent part. If the mass in the crucible be of a brownish red colour, it contains oxid of iron: a bright green colour announces the presence of manganese, especially if a small quantity of the mass, when dissolved in water, communicates to that fluid the same colour. If the mass is of a yellowish green, the oxid of chrome may be present.

II.—When the mass has been thoroughly fused or kept in a red heat for at least 2 hours, remove the crucible out of the fire, and when nearly cold, pour water into it gradually, in order to detatch the mass from the crucible; transfer the whole into a flask, pour 4 times its quantity or more of water over it; boil the mixture for about ½ an hour, and then suffer it to subside.

III.--Having done this, pour gradually muriatic acid into the before obtained solution, without previously separating the insoluble part, if any. The first portion of acid which is added occasions a flocculent precipitate, then an effervescence takes place, and a copious precipitate immediately follows, which however is no sooner formed, than it is re-dissolved. On adding more acid the portion of the mass which resisted the action of water, and which was not dissolved in process II. will become dissolved. If it consists of alumine, it will be taken up silently by the acid; if it be lime, barytes, or strontia: it will be dissolved with effervescence.

Remark.—From the phenomena attending the process of the solution of this mass in muriatic acid, some indications may be derived. If the solution be colourless, the stone contains no metallic substance, or only a minute quantity. If its colour be purplish red, it contains manganese: orange red is a sign of oxid of iron: gold yellow shows chrome.

IV.—To separate the different earths, &c. contained in the solution, evaporate it to dryness; when the evaporation is approaching towards its completion, it assumes a gelatinous appearance, it must then be deligently stirred with a glass rod till it is almost dry.

V.—Transfer the mass into a large quantity of water, boil the mixture for a few minutes, and then filter it, wash the insoluble residue left on the filter repeatedly, dry it and expose it to a red heat, its weight shows the quantity of silex contained in the stone. If it is pure silex, it will be perfectly white, entirely insoluble in sulphuric, nitric, and muriatic acids. If it be coloured, it is contaminated with some metallic oxid, and shows that the evaporation to dryness has been performed with two much heat. From the metallic oxid, it may be purified by digestion in muriatic acid, and then washed, and dried as before. The acid expended in washing may be added to the fluid which passed through the filter in obtaining this earth.

VI.—The fluid from which the silex has thus been obtained, is then to be concentrated by evaporation, and mingled with a heated solution of carbonate of potash, till no more precipitate ensues. The precipitate must be separated by the filter, washed, and dried. It may contain, alumine, lime, magnesia, glucine, and yttria, besides metallic oxids.

VII.—Transfer the precipitate obtained in the last process into a solution of potash, and boil it for ½ an hour. If alumine and glucine were present, they will both be dissolved in the potash, while the other substances remain untouched in the form of a powder.

VIII.—To separate the alumine decompose the solution, by the addition of an acid, taking care to add the acid employed in excess, so that the precipitate which first appeared becomes re-dissolved. Having done this, drop into it a solution of carbonate of ammonia, in such quantity that the liquid tastes of it. By this addition the whole of the alumine will be precipitated in white flakes, and the glucine will remain dissolved, provided the quantity of carbonate of ammonia used be not too small. The liquid must now be filtered, and the alumine washed, dried, and ignited; its weight may then be ascertained.

IX.—The fluid from which the alumine has been separated, may be boiled for some time: the glucine, if it contains any, will be precipitated, which may be dried, and weighed.

X.—The insoluble part left in process VII. may now contain lime, magnesia, and some metallic oxid; let it be dissolved in diluted sulphuric acid, and the solution evaporated to dryness; on the dry mass, pour a small quantity of water, and digest it for a few minutes, the water will dissolve the sulphate of magnesia, and the metallic sulphates; but the lime combined with the sulphuric acid will remain undissolved; let it be heated red hot in a crucible, and the quantity of lime determined, as directed before, page 143.

Remark.—If yttria be suspected, let the residuum of process VII. be treated with carbonate of ammonia, which will dissolve the yttria, and leave the other bodies; then proceed as above.

XI.—The solution from which the lime has been separated must next be copiously diluted with water; add a small excess of acid, and then drop into it a solution of carbonate of potash as long as a precipitate ensues. This will separate the oxids of iron, chrome, and nickel; but the oxid of manganese, and the magnesia, if any be present, will remain dissolved.

XII.—To separate the oxid of manganese, from magnesia, pour into the fluid obtained in the last process, hidro-sulphuret of potash: the manganese will be precipitated, but the magnesia will remain dissolved. The precipitated manganese must be heated to redness, and weighed.

XIII.—To the fluid of the last process from which the manganese has been separated, add a solution of potash; the precipitate which now falls down is magnesia: let it be washed, dried, and heated to redness.

XIV.—In order to obtain the metallic oxids, boil the insoluble residue left in process XI. repeatedly in nitric acid to dryness.

XV.—Transfer the dry mass into a concentrated solution of potash. The oxid of chrome acidified in the last process, will thus unite to the potash, but the other oxids will remain untouched; decant the fluid from the insoluble residue.

XVI.—To separate the oxid of chrome, add to the solution muriatic acid in excess, and evaporate the fluid till it assumes a green colour; then on adding a solution of potash, the oxid of chrome falls down, because the quantity of oxigen required for its acidification has been separated by the muriatic acid, let the precipitate be dried and weighed.

XVII. Let the insoluble residue of process XIV. be next dissolved in muriatic acid, and to the solution add liquid ammonia in considerable excess; the oxid of iron will be precipitated; let it be washed, dried, and weighed.

XVIII.—The oxid of nickel which remained in solution, on account of the excess of ammonia, will now fall down: on evaporating the fluid to dryness, its weight may be ascertained in the same manner with the other ingredients, and the analysis of the stone is now compleated.

ANALYSIS OF SOILS.

In the preceding pages it has been endeavoured to exhibit a view of analysing earths and stones, as constituting particular genera, and species; we shall now consider the method of analysing soils. For the best methods of doing this, we are wholly indebted to Kirwan, from whose essay on philosophical agriculture, entitled "The manures most advantageously applicable to the various sorts of soils, &c." the following lines have been transcribed.

Land considered as the basis of vegetation, is called *soil*. Soils consist of different combinations of earths, intermingled with a portion of animal and vegetable matter. Its composition may be determined in the following manner:

Process I.—In dry weather, in the spring, when the soil is not over moist nor dry, let a surface of 16 square inches be cut through to the depth of 8 inches; by a right angled spade, formed for this particular purpose. Of the parallelopiped thus dug up, the two inches next the surface should be cut off, to get rid of the grass, and the greater part of the roots; we shall then have a solid 6 inches long, and 16 square at the end = 96 cubic inches. Let this be weighed; its weight will serve to find the specific gravity of the soil; for if 96 cubic inches weigh n pounds, 1728 (a cubic foot) should weigh x pounds, and x divided by 75, 954 will express by the quotient the specific gravity of the soil. To render this and the subsequent operations more intelligible, I shall illustrate each by an example: Suppose the 96 cubic inches to weigh 6, 66 pounds, then 1728 cubic inches should weigh 120 lb. and

$$\frac{120}{75.954} = 1.579$$

II.—The earth being weighed, is next to be broken down and freed from all stony substances above the size of a pippin, and the remainder well mixed together, to render the whole as homogenous as possible; then weigh the stones that were picked out, and find the proportion belonging to each pound of the residuary earth; call this the *stony supplement*, and denote it by *S*. Thus if the stones weigh 1 lb.=12 oz. the remainder or mere earth, must weigh 5.66 lb. and if to 5.66 lb. there belong 12 ozs of stone, to 1 lb. must belong 2. 12014 ozs. or 2 ozs. 57.66 grains = 1017.66 grs. This then is the stony supplement of each succeeding pound $=S$.

III.—Of the earth thus freed from stony matter, take 1 lb.—S. (that is the above case 1 lb.—2 oz. 57 two-thirds grs.) heat it nearly to redness in a flat vessel, often stirring it for half an hour, and weigh it again when cold. Its loss of weight will indicate the quantity of water contained in 1 lb. of the soil. Note this loss, and call it the *watery supplement*$=W$. Suppose it in this case 100 grains.

IV.—Take another pound of the above mass freed from stones, deducting the stony and watery supplements; that is 1 lb.—S—W. or in the above case 1 lb.—2 ozs. 57$\frac{2}{3}$ grs. for stone, and—100 grains for water; consequently 1 lb. —2 ozs. 157$\frac{2}{3}$ grs. reduce it to powder: boil it in four times its weight of distilled water for half an hour; when cool, pour it off, first into a coarse linen filter to catch the fibrous particles of roots, and then through paper, to catch the finer clayey particles diffused through it: set by the clear water, add what remains on the filter to the boiled mass: if it be insipid, as I suppose it to be, then weigh the fibrous matter, and call it the *fibrous supplement* = F. Suppose it in the example in hand to weigh 10 grs.

V.—Take two other pounds of the mass freed from stony matter, No. II. subtracting from them the weight of the stony, watery, and fibrous substances already found; that is, 2lb. —2 S—2 W—2 F; pour twice their weight of warm distilled water on them, and let them stand twenty-four hours or longer; that is, until the water has acquired a colour, then pour it off and add more water as long as it changes colour; afterwards filter the coloured water and evaporate it to a pint or half pint; set it in a cool place for three days, then take out the saline matter, if any be found, and set it by.

VI.—Examine the liquor out of which the salts have been taken; if it does not effervesce with muriatic acid, evaporate it to dryness, and weigh the residuum; if it does effervesce with acids, saturate it with the sulphuric or muriatic and evaporate it to one fourth of the whole; when cool, take out the saline residuum, evaporate the remainder to dryness, and weigh it: this gives the coaly matter, which may be tried by projecting it on melted nitrate of potash with which it will deflagrate. (See analysis of coals.) The half of this coaly matter call the *coaly Supplement* of 1 lb. I shall suppose it to amount to 12 grs. and denote it by C.

VII.—The filtered water, process IV. is next to be gently evaporated to nearly one pint, and then suffered to rest for three days in a cool place, that it may deposit its saline contents, if it contains any; and these being taken out, the remainder must be evaporated nearly to dryness, and its saline matter examined. How this should be done, I shall not mention, the methods being too various, tedious, and of too little consequence; few salts occur except gypsum, which is easily distinguished. The water may be examined as to its saline contents when it is evaporated to a pint: according to the rules to be mentioned hereafter. If any salts be found, call them the *saline supplement*, and denote them by *S'*. I shall suppose them here = 4 grains.

VIII.—We now return to the boiled earthy residuum, process IV. which we shall suppose fully freed from its saline matter; as, if it be not, it may be easily rendered so, by adding more hot water: let it then be dried as in process III. is mentioned. Of this earthy matter thus dried, weigh off one ounce, deducting $\frac{1}{12}$ part of each of the supplements, *S. W. F. C.* and *S′*; that is, in this case

$$\frac{1017,66}{12} = + 84,405 \frac{100}{12} = 8,333 + \frac{10}{12} =$$

$$8,333 + \frac{12}{12} = 1 + \frac{4}{12} = 0,3333 = 95 \text{ grs. in all}$$

—then 408—95=385 grains will remain, and represent the mere earthy matter in an ounce of the soil.

IX.—Let this remainder be gradually thrown into a Florence flask, holding one and an half as much nitric acid as the earth weighs, and also diluted with its own weight of water; the next day the flask with its contents being again weighed, the difference between the weights of the ingredients and the weights now found, will express the quantity of air that escaped during the solution. Thus in the above case, the earth weighing 385 grains, the acid 577.5 grains, and the water 577.5 grains, in all 1540 grains, the weight after solution should also be

1540, if nothing escaped; but if the soil contains calcareous matter, a loss will always be found after solution. Let us suppose it amounts to 60 grains.

The weight of air that escaped, furnishes us with one method of estimating the quantity of calcareous matter contained in the earth assayed; for carbonate of lime contains 40 per cent. of carbonic acid; then if 40 parts of carbonic acid indicate 100 of calcareous matter, 60 parts carbonic acid will indicate 150.

X.—The solution is then to be carefully poured off, and the undissolved mass washed and shaken in distilled water; the whole thrown on a filter, and washed as long as the water that passes through has any taste. The contents of this water should be precipitated by a solution of carbonate of potash: this precipitate also being washed and dried in a heat below redness, should then be weighed. Thus we have another method of finding the weight of the calcareous matter.

XI.—The undissolved mass is next to be dried in the heat already mentioned, and the difference between its weight and the weight of the whole earthy mass before solution should be noted, as it furnishes a third method of discovering the weight of the calcareous matter of which it is now deprived. Supposing this to amount to 150 grains, the weight of the undissolved residuum should in the above case be 383—150=235 grains.

XII.—Reduce the dried mass into the finest powder, throw it into a Florence flask and pour on it three times its weight of sulphuric acid, digest it in a strong sand heat, and at last raise the heat so as to make the acid boil; afterwards let it evaporate nearly to dryness: when cold, pour on it gradually six or eight times its weight of distilled water, and, after some hours, pour off the solution on a filter; the filter should previously be weighed, the substance found on the filter being weighed (subtracting the weight of the filter) gives the quantity of silicious matter; and this weight subtracted from that of the dried mass, gives that of the clay. In this case I will suppose the silicious mass to weigh 140 grains, then the clay should weigh 95 grains.

Then the composition of one pound of the soil is as follows:

Stony matter	1017.66
Water	100
Fibres of roots	10
Soluble coal	12
Saline matter	4
Silex	140 × 12 = 1680
Clay	95 × 12 = 1140
Calcareous earth	150 × 12 = 1800
	5763.66

And in centesimal proportion	Stony matter	18	
	Fine silicious	29	
			47
	Clay		22
	Calcareous earth		31
			100

Its retentive power is 82.25: hence I should judge it to be unfertile in this climate, unless situated on a declivity, with an unimpeded fall. It may be called a *clayey loam*.

Mr. Young discovered a remarkable circumstance attendant on fertile soils: he found that equal weights of different soils, being dried and reduced to powder, afforded quantities of air by distillation somewhat corresponding to the ratios of their values. This air was a mixture of carbonic acid and hidrogen gas, both proceeding, most probably, from the decomposition of water by the coaly matter in the soil. The distillation should be made from a glass retort. He found an ounce of dry soil, value five shillings, produced ten ounce measures;

Of value of from 5 to 12s. produced 28 oz.
12 — 20 42
above 20 66

This appears to be a good method of estimating the proportion of coaly matter in soils that are in full heart; that is, not exhausted, and freed from roots, &c. Another mark of the goodness of a soil is the length of the roots of wheat growing in it; for these are in an inverse proportion to each other, as, if the land be poor, the wheat will extend its roots to a great distance in quest of food; whereas, if it be rich, they will not extend above five or six inches; but of these and some other empyrical marks, I shall say no more, as they do not tell us the defects of the soils.

CLASS III.

MINERAL OR NATIVE SALTS.

By the name of mineral or native salts, we understand strictly, speaking, all those mineral substances which are found in nature, consisting of an earthy, metallic, or alcaline base, combined with an acid. They naturally divide themselves into several genera, namely; calcareous salts, comprehending the combination of calcareous earth, with different acids ; such as carbonates, sulphates, phosphates, fluates, and borates of lime. Barytic salts, comprehending the combinations of barytic earth, with sulphuric, and carbonic acids, strontian salts, or strontian earth, united to the same acids, &c. Most of these have been considered under the class of ores, earths, and stones. We have therefore to consider here merely, the combination of alcalies with acids, which in part, usually are called mineral salts; for they possess the properties of saline bodies, in a more striking degree; and with that view we shall point out the method of ascertaining whether an unknown mineral, contains some saline matter, or not; and to what species of salt it properly belongs.

GENERAL ANALYSIS OF NATIVE OR MINERAL SALTS.

Process I.—In order to investigate whether an unknown mineral contains some saline matter, put a determinate quantity reduced to an impalpable powder, into a flask, pour over it 40 times its weight of water, digest the mixture in a temperature of about 130°, and agitate it frequently. Having stood for about 6 hours, decant the transparent fluid, separate the insoluble part, by pouring it on a filter, whose weight is known; dry, it in a heat not exceeding 212°, and ascertain its weight. If the weight be considerably less than the joint weight of the filter and powder, before digestion, we are certain that some salt has been taken up by the water; the deficiency of weight will indicate its quantity. Being thus convinced, that the substance under examination, belongs to the class of minerals, properly called salts: we have next to find out the nature of it, more accurately, in the following manner:

II.—Drop into a wine-glass full of the solution, obtained by digesting the mineral in water, as directed before, a few drops of tincture of litmus, or immerse into it a piece of litmus paper, and notice if the blue colour of the tincture, or of the paper becomes altered, or not.

If the paper becomes red, the fluid contains an uncombined acid, or a salt with excess of acid. In order to ascertain the nature of this acid which is present, drop into the solution muriate of barytes, if an insoluble precipitate ensues, sulphuric acid is present. But if the precipitate is soluble in muriatic acid, phosphoric acid may be expected. If nitrate of silver occasions a precipitate, muriatic salts, or muriatic acid was present.

III.—If water that has been suffered to act on a saline substance, changes the yellow colour of turmeric paper brown, it contains an alcaline substance, and the salt belongs to the class of alcaline salts.

III.—If a substance is found not to change the colour of the turmeric brown, or that of litmus red, and if it does not effervesce on the addition of an alcali, the salt is then distinguished to be a neutral, or compound salt, composed of an acid, and a certain base; we have therefore to determine the nature of the base, that is to say, to find out whether the salt has a metallic, earthy, or an alcali for its basis. This may be accomplished in the following manner:

ANALYSIS OF SALTS WITH METALLIC BASES.

Process I.—Drop into the solution obtained as in the last process, a few drops of prussiate of potash, if a copious blue precipitate ensues, it then contains metallic parts, and belongs to the salts called metallic salts.

II.—To ascertain the genus to which it belongs, by determining the acid, by which its basis is neutralized; for this end, we add to a little of the saturated saline solution, an equal portion of alcohol; if this occasions the salt to precipitate, and if a few drops of muriate of barytes, added to a little of the dissolved salt, occasion a copious precipitate, we know that the acid present is sulphuric acid, and that the salt belongs to the genus called *sulphates*.

III.—To determine the metallic oxid, with which the acid was combined, we add to it first a solution of carbonate of ammonia; if this occasions a blue precipitate, which is redissolved by an excess of ammonia, add an acid, a little in excess; we then immerse into it a cylinder of iron, and suffer it to stand undisturbed for some days. If the iron cylinder becomes covered with a coat of copper, we then have found that the salt had copper for its basis, and therefore belonged to that species which is called *sulphate of copper.*

IV.—But if these phenomena are not perceived, we let fall into the solution a few drops of prussiate of potash. If this produces a blue precipitate, the basis is then supposed to be iron, and in this case it must also occasion a black colour when mixed with a tincture of galls. If such a phenomena takes place, the salt belongs to that species of salts called *sulphate of iron.*

V.—If neither of these phenomena ensue, and the fluid exhibits a rose colour, we add a few drops of tincture of galls, if this occasions a blue precipitate, and a precipitate is also produced by the addition of potash, which when fused with borax before the blow-pipe, produces a blue glass, we then have ascertained the basis of the salt, to be cobalt, and this with sulphuric acid before detected, makes it to be that species called *sulphate of cobalt.*

VI.—But if neither of these marks should be perceived, we place a polished cylinder of copper into the concentrated solution; and if this occasions a white metallic precipitate upon the surface of the copper cylinder, which can be volatilized again by exposing the cylinder to heat, we then know the basis to be mercury; having ascertained the principal component part of the salt, which is distinguished by the name of *sulphate of mercury.*

VII.—But if the fluid should not prove any of these mentioned properties of mixture, and if it yields a white salt on evaporation, if prussiate of potash added to it, produces a greenish white precipitate, and if a cylinder of iron, and copper when placed in the solution, occasione no precipitate, we then suppose the substance to be the species called *sulphate of zinc.* These are the principle metallic salts, hitherto found in the earth.

ANALYSIS OF SALTS WITH ALCALINE BASES.

Process I.—If a solution of salt in which prussiate of potash does not occasion a blue precipitate, the salt is of a different nature from those mentioned before. We have then to find out its composition, by adding to it a solution of carbonate of potash, or soda. If this occasions no precipitate, the salt then probably belongs to the neutral salts, with alcaline bases. It may however happen, that salts of that kind exist in the solution, associated with salts of a metallic or earthy base. In this case the examination becomes difficult; because the alcali added, which acts as the re-agent to precipitate the two last, makes it doubtful to ascertain whether the neutral salts were formed during the process, or whether they originally existed in the solution. The following method, recommended by Mr. Henry, will in that case prove useful.

II.—Precipitate the metallic oxid, by adding to the solution prussiate of ammonia, and separate the earth, by adding to it a solution of carbonate of ammonia, taking care to have previously heated the fluid to at least 180°, or upwards, in order to insure the decomposition of magnesian salts, which cannot be effected by carbonate of ammonia in the cold. Separate the liquor by filtration, and evaporate it to dryness; then expose the dry mass to a dull red heat, in order to expel the ammoniacal salts. The salts, with fixed alcaline bases, will remain behind. By this process, indeed it will be impossible to ascertain whether ammoniacal salts were originally present; but this may be learned by adding to the salt under examination, before its solution in water, some potash, which, if ammonia be contained in the salt, will produce its peculiar odour ; and if it precipitates a solution of platina, the salt in that case belongs to the class of salts called *ammoniacal salts.*

III.—In order to ascertain the acid with which the ammonia is combined, we mingle a solution of the salt with lime-water. If a precipitate ensues, which on adding a few drops of muriatic acid, again becomes dissolved with effervescence, the salt belonged to the class of salts, called *carbonate of ammonia.*

IV.—If on the contrary no such effects take place, but a copious precipitate ensues on adding to the solution a few drops of muriate of barytes, we then conclude that the salts is *sulphate of ammonia.*

V.—But if neither of these changes ensue, we drop into the solution a few drops of sulphate of silver; if this produces an insoluble white precipitate, the salts consist of muriatic acid and ammonia, and is consequently *muriate of ammonia.*

VI.—But suppose ammonia did not enter into the composition of the salt, and had not been detected as stated before, but another alcaline basis was present; we then add to the solution of the salt in water, a little tartareous acid: if a turbidness ensues, the basis of the salt is potash, and the salt of course belongs to the class of salts with a basis of *vegetable alcali*; but if no such effect takes place, we conclude that the basis of the salt is soda, and that it belongs to the class of salts, with a basis of the *mineral alcali.*

VII.—If a little of the salt, when mixt with charcoal powder, and thown into an ignited crucible deflagrates, we know that nitric acid is present, and that it belongs to the class of salts called *nitrates.*

The presence of other acids may be detected as stated before.

ANALYSIS OF SALTS WITH EARTHY BASES.

Process I.—If a solution of salt in which prussiate of potash occasions no precipitate, affords a copious precipitate by the addition of carbonate of potash, it proves that the salt has an earth for its basis, and consequently belongs to the class of *earthy salts*.

II.—In order to ascertain the acid which is combined with the earth, we proceed as directed before, in the preceding pages.

III.—We next endeavour to ascertain the earths: if we find that the precipitate is soluble in sulphuric acid, and yields with it, by the addition of a small quantity of alcali, a salt which has a sweet styptic taste, and which has the properties of alum, we know that the basis of the salt was alumine, and that it belongs to the class of *salts*, called *alum*.

IV.—But if the salt obtained by neutralizing the earth, with sulphuric acid, has a bitterish taste, and becomes decomposed by carbonate of potash, and yields a precipitate which when ignited remains soluble in nitric and acetic acids; it then belongs to the class of salts, having magnesia for its basis, called *magnesian salts*.

In this manner we may ascertain the different salts which have hitherto been found amongst the mineral substances. There are others met with in mineral waters, the presence and nature of which must be ascertained in a different manner. The salts here considered are only such as are found each in a separate state, and which appear homogeneous.

Before we conclude this subject we shall exhibit an

EXAMPLE OF AN ANALYSIS OF A MIXTURE OF DIFFERENT SALINE SUBSTANCES.

Suppose we had ascertained by previous experiments, in the way mentioned in the foregoing part, that an earth contained a mixture of different salts, viz. *sulphate of magnesia, muriate of potash, sulphate of iron, sulphate of potash,* and, *sulphate of soda*; we then may proceed in the following way:

Process I.—Let a certain quantity of such earthy substance which has been previously dried for two hours in the heat of boiling water, be extracted and freed from saline parts, by digesting it with about 50 parts of distilled water, in a glass matrass; filter the whole, and wash the remainder upon the filter, with a little water, then dry it in the same heat, and for the same time as before, and ascertain its weight. The loss, indicates the quantity of saline parts which were contained in it.

II.—Let a certain quantity of the saline liquid be evaporated to dryness by a gentle heat.

III.—Digest the residue with high rectified spirit of wine, as long as the spirit will dissolve any part of the salt. This spirituous solution mix with a little water, and again separate the spirit by distillation.

IV.—Evaporate the remaining aqueous solution nearly to dryness, and suffer it to crystallise; let the salt be dried in the same degree of heat as the earth had been exposed, and ascertain its weight, which will indicate the proportion of the salt which was taken up by the spirit, and which was muriate of potash; this salt may be again decomposed, by dissolving a little of it in water, and adding to it sulphate of silver: this will occasion a precipitate which indicates the muriatic acid; and carbonate of potash added to it, will occasion no earthy precipitate, if the salt was merely composed of muriatic acid and potash.

V.—The salt which was not acted upon by the spirit, is then to be dissolved with a sufficient quantity of distilled water, mingled with a little acetous acid, and prussiate of lime gradually dropped into it, until it does not occasion any more blue precipitate. The precipitate thus formed, must be collected on a filter, washed with a little water, dried, and made red hot in a small crucible, whose weight is previously ascertained, and which has been ignited before the precipitate was put in; after which, the crucible is taken out of the fire and again weighed, thus the proportion of the oxid of iron is ascertained.

VI.—The remaining liquid from which the iron is separated, is gradually to be mixed with acetite of barytes as long as any precipitate is thereby occasioned: the precipitate consists of the barytes contained in the acetous solution which was added, and of the sulphuric acid contained in the salts; the whole is then put upon a filter, the precipitate carefully collected, dried, and its weight ascertained. 100 grains of such precipitate, are equal to 23.5 grains of sulphuric acid.

VII.—The remaining solution consists now of *magnesia, potash, soda, and acetous acid*; to separate them let it be evaporated to dryness, and ignite it in a smooth crucible, until the acetous acid has been driven off by the heat; the remaining substance is to be extracted by warm water, as long as the water takes up any of it; the whole must then be transferred upon a filter, and the earth, which was the magnesia, be collected, dried, ignited, and its weight ascertained.

VIII.—The salt which the water had extracted from the residue, is again saturated with acetous acid, and if after stirring the solution, any earthy precipitate is observed, it is to be filtered again, and the earth collected upon the filter; it is the portion of magnesia which had been taken up by the alcali, which is likewise to be dried and added to the weight of the magnesia obtained before.

IX.—The filtered liquid is again evaporated by a gentle heat to dryness and afterwards digested in alcohol. This will take up the potash combined with muriatic acid, and leave the soda behind; the alcoholic solution is evaporated to dryness, and re-dissolved in distilled water; and then mixed with acetite of lead, until all the muriatic acid is thereby separated; the precipitated muriate of lead is then separated by filtration, and the filtered liquid evaporated to dryness; afterwards ignited a little in a small smooth crucible, whose weight has been previously ascertained; when the acetous acid has been driven off by heat, the crucible is removed, and when cooled, it is immediately weighed: the overplus of the weight of the crucible indicates the weight of the potash. The muriate of soda, which was not dissolved, is likewise treated in the same way, and thus the quantity of the soda ascertained.

If we now take each of the four separated ingredients, namely the magnesia, soda, potash, and the iron, and saturate each separately with sulphuric acid, and then crystallise them; we become enabled by that means to ascertain the quantity of each of the salts in the state as they were contained in the earthy substance, pretty accurately.

This being a nice process, requires great accuracy; and the rules for accomplishing it, would require more room than could be allotted for it in this essay.

CLASS IV.

INFLAMMABLE FOSSILS.

THE class of minerals remaining to be noticed, are those called inflammable or combustible fossils. The principal combustibles of this class are, coals, sulphur, amber, and bitumen.

CHARACTERISTIC PROPERTIES OF INFLAMMABLE FOSSILS.

Inflammable flossils are such mineral substances as burn more or less easily, or whose principal character is inflammability at not very high temperatures. They are all insoluble, at least in their totally in alcohol, as well as in water, and acids; but yield generally more or less to some species of volatile oil, or to sulphuric ether. Their specific gravity is below or scarcely exceed 2°, unless loaded with foreign matter.

NATURAL HISTORY OF COALS.

Coals are commonly found in hilly situations, always under strata of grit, which is a mixture of sand and clay; or under schistus, which is an indurated clay, splitting into layers, forming either slates, or a substance called shivers; according to its fracture. Coals are found on the mountains in strata, from a few inches to some feet in thickness, alternating with strata of grit stone and shistus. The beds of coals run in various directions, generally with a dip or inclination from the horizontal position. They are frequently intercepted by columns of other matter; and the continuation of the bed may be higher, or lower, than the part from which it has been, or seems to have been separated. The continuation too sometimes take the same, sometimes a very different degree of inclination, or dip. It generally happens that the first stratum of coals, that we come to, is not worth working, either from the inferior quality of the coal, or from the stratum being of too little depth. From the degree and direction of the dip, and the level of the country; much information is to be obtained, concerning the proper places for opening the pit. A variety of circumstances require to be taken into consideration, to work a coal mine to the greatest advantage, or to determine whether a mine ought to be worked at all. Even in countries or in those parts of the country, where none have been found, very probable conjectures may be formed concerning their presence, by attending to the soil, to the general appearance of the country, and to the kind of clay, sand, or other earth, that is found when the soil is removed. There are certain appearances that indicate the presence of coals ; but these indications are subject to variations, and often appreciable by other rules. The business of mining in this department, is therefore intricate as that of ores, and none ought to enter upon it, without a practical knowledge of it, or the assistance of a practical miner.

With respect to the origin of coals, the most probable supposition is this :

That they originate from vegetables; but a few forests being buried in the earth are not sufficient to form the mountains of coal which exist in its bowels. A greater cause more proportioned to the magnitude of the effect is required; and we find it only in that prodigeous quantity of vegetables which grow in the sea, and is increased by the immense mass of those which are carried down by rivers. These vegetables carried away by the currents, are agitated, heaped together, and broken by the waves, and afterwards become covered with strata of argillaceous earth, or sand; they undergo a gradual decomposition, and form so many strata of coal, placed alternately with strata of clay and sand. It is indeed easier to conceive how these masses of vegetables may form strata of coal, than that remains of shells, should form so great a part of the globe.

That the coal itself is of vegetable origin, is fairly inferred from a variety of vegetables, remains, and impressions of animals, that are both found in the strata of coal, and in the earthy strata, above and below them. That it is of submarine origin, also appears obvious from the presence of shells, the impressions of fish, and other productions of the ocean. The popular opinion that coals grow like vegetables, so that the mines that are exhausted may be opened again and worked after a series of years, is too erroneous to need any formal refutation. We need not however be alarmed for the want of future generations, as to this useful article. The immence beds of coal yet untouched will amply supply many thousands of generations to come; and there is no doubt but the same process that produced what we at present use, is still continued, and that some future convulsions of nature, bring to light new coal mountains perhaps from the bottom of the ocean; for that it is most probable is the place where nature had fixed her laboratory, for preparing this fuel for distant ages.

ANALYSIS OF INFLAMMABLE FOSSILS.

The complete analysis of inflammable fossils would require a particular treatise: our object however is to determine in a ready manner the relative proportion of combustible matter, or carbon, which different species are capable of yielding in order to be enabled to judge in some respect which are most advantageous in ordinary processes of combustion: for the method of accomplishing this we are indebted to Kirwan. The only combustible substance of what it will be necessary to speak for that purpose, are coals.

Coals, at least those which are chiefly imployed for fuel are composed of carbon or charcoal, bitumen, some portion of earth, and a small quantity of metallic matter.

The proportion of carbon may be ascertained by observing the quantity of nitrate of potash which a given quantity of coal is capable of decomposing. This may be effected in the following manner. Let 500 grains, or more of perfectly pure nitrate of potash be fused in a crucible, and when red hot, let the coal to be examined, coarsely powdered, be projected on the fused nitre, by little at a time, not exceeding one or two grains. Immediately when the detonation produced by the addition of one projection of coal has ceased, add a new portion till it produces no farther effect. The proportion of carbon in the coal is directly proportionate to the quantity required for the decomposition of the nitrate of potash. Thus Kirwan found that 12.709 of carbon are necessary to decompose 100 of nitrate of potash: it will be easy to deduce the quantity of carbon, in a given weight of coal, from the quantity of nitrate of potash which it is capable of decomposing. Kirwan found that 480 grains of nitrate of potash required 50 of Kelkenny coal to decompose it by this method. Therefore 10 grains would have decomposed 96 of nitrate of potash; precisely the quantity of charcoal which would have produced the same effect. Therefore Kilkenny coal is composed almost entirely of carbon. Cannel coal, when burnt in this manner, left a residuum of 3.12 in the 100 parts of earthy ashes, 66.5 of it were required to decompose 480 grains of nitrate of potash, but 50 of charcoal would have been sufficient: therefore 66.5 grains of Cannel coal contain 50 grains of charcoal, and 2.08 of earth; the remaining 14.42 grains must be bitumen.

In a similar manner the composition of any other coal may be ascertained.

The proportion of earthy, or metallic ingredients may be ascertained by burning the coal, with free access of air. What remains unburnt must be considered as an impurity, its weight may be ascertained, and the nature of the earthy and metallic substances analysed, according to the rules laid down, in the preceding pages of this essay.

With the close of this subject terminates the plan of this essay. In the preceding pages it has been endeavoured to exhibit a view of the best methods of analysing minerals. It is but a sketch which has been given, for to have entered more fully into every detail, would have immeasurably swollen out this pamphlet. The design was merely to furnish examples of the best methods of examining chemically mineral substances in general, in order to refer them to their respective places, according to any of the adopted systems of mineralogy.

CHEMICAL DEMONSTRATIONS

OR

Private Lectures,

ON

PRACTICAL CHEMISTRY.

By FRED. ACCUM.

THOSE who are familiar with Chemistry will readily allow, that little progress can be made in that Science without actually applying to its operative part. It is not merely a knowledge of the general laws and leading facts that contitutes the chemist; his skill must be acquired by actual practice and manual dexterity. The latter cannot be obtained from books, nor from PUBLIC LECTURES, calculated for a mixt audience.

The student may in the latter cases indeed learn the language of chemistry; he may be taught the explanation of some of the most striking phenomena; he may even become enabled to repeat some detached brilliant experiments which he has witnessed; but he will not be capable of appreciating the whole doctrine, nor conceive the union and regular connexion of all the subordinate parts which constitute the domain of the science. If he should attempt to make new experiments himself, he will soon become sensible of the danger to which he exposes himself of falling a sacrifice to his want of experience.

These truths show, that the only effectual means of facilitating the study of that science consist in applying his hands to the experimental part of the science, in order to be enabled to observe all those minute phenomena which result from the action of the different bodies presented to each other, and to become familiar with the nature, manipulations, and practical use of the chemical apparatus. This however cannot be done in PUBLIC LECTURES, nor at a distance from the chemical furnaces. He must for that purpose have access to the laboratory of the operative chemist.

It is with this view that I offer to the amateurs of the science, a Course of PRIVATE CHEMICAL DEMONSTRATIONS, the aim of which is to elucidate by actual practice, all the general, and particular operations of chemistry, and to exemplify the application of the science to all those individual arts and manafactures, which are immediately dependent on chemical principles.

In order to accomplish this as perfectly as possible, the processes of the laboratory will be employed, to disengage from the raw materials of nature all those substances which form the subjects of chemical research, and to point out their application to the purposes of the arts. The best methods of preparing chemical preparations in general, as well as pharmaceutico-chemical substances, will be taught; the mode of detecting their sophistication shown; and the art of analysing earths, minerals, soils, &c. elucidated by actual experiments.

I flatter myself that by thus blending the theory of the science with practical instructions, those who wish to embark in chemical pursuits, merely for the sake of general information or amusement, will find the study pleasing and easy; whilst those, who are desirous of pursuing the experimental part beyond the limits of the amateur, will witness the best processes of the practical chemist, and have opportunity of noticing all those particulars which are absolutely requisite for the processes of the laboratory,—which are not to be met with in books of science, — and which the caprice and interested motives of the artist have kept from the cabinet of the philosopher, who stands insulated from the ordinary pursuits of life.

In order to adapt these Lectures as much as possible to the objects of different individuals, the science will be divided into separate departments, in a great measure independent of each other, namely:

POPULAR CHEMISTRY,

Embracing the general chemical examination of the principal phenomena of nature, and elucidating, in a series of striking experiments, the theory of attraction and repulsion — The doctrine, phenomena, and general effects of heat, and its artificial application — The phenomena of freezing and thawing — The theory of combustion, culinary fires, lamps, &c. —The best construction of grates, stoves, furnaces, &c. — The theory and nature of light, and the cause of colours—The chemical agency of light, &c.—The nature and production of gases, and the phenomena which they display in their evolution, and in their combination in the great operations of nature and art—The examination of the atmosphere, its analysis and synthesis—Eudiometry—The theory of respiration and animal heat—The formation and composition of water—The production of rain, snow, hail, fogs, dews, &c.

OPERATIVE CHEMISTRY,

Comprehending a summary exhibition of all the principal operations of the scientific laboratory—Description and manipulation of the chemical apparatus and instruments in general—Difference of the apparatus of the operative chemist from those of the experimental philosopher—Preparations of re-agents and tests, and experiments elucidating their application and the phenomena of their action—Chemical analysis—Best methods of preparing pure acids, alcalies, earths, metals, saline compounds, and other articles, made use of in experimental chemistry, pharmacy, and by manufacturers and artists.

MINERALOGICAL CHEMISTRY,

Elucidating the general out-lines of mineralogy—Structure of the earth—Geology—Division of minerals—Chemical examination of an unknown mineral substance—Analysis of ores of metals — Analysis of stones, earths, carbonaceous substances, inflammable fossils, and mineral bodies in general—Smelting of ores—Assaying and refining of metals—Formation of alloys, casting of metallic compounds, &c.

AGRICULTURAL CHEMISTRY,

Explaining the general theory of vegetable chemistry — Phenomena of germination—Commencement of vegetative life—Nutrition and food of plants —Nature and chemical analysis of various kinds of manures, and theory of their beneficial effects—Chemical examination of different sorts of soils, in order to determine their fitness for agricultural purposes—Theory of the change of crop, &c,—Structure of vegetables in general—Functions of plants in the economy of nature—Examination of the different substances which form the body of plants—Analysis of vegetables in general, &c.

GALVANISM.

History of galvanism—Phenomena, and effects of the agency of galvanism in general—Galvanic apparatus—Pile of Volta—Galvanic batteries—Theory of the construction of galvanic instruments—Comparative experiment of their power of action — Agency and phenomena of galvanism on dead and living matter—Chemical effects of galvanism—Decomposition of water, alcohol, oils, &c.—De-oxidation of acids, and metallic oxids—Combustion of metals—Accension of inflammable and explosive compounds—Comparison of galvanism with electricity, &c.

For further particulars, application may be made at the Laboratory of the Author, 11, *Old Compton Street, Soho.*

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